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VIENNA INTERNATIONAL EXHIBITION, 1873.

REPORT

ON

IRON AND STEEL.

BY

WILLIAM P. hipps BLAKE,

DELEGATE TO THE INTERNATIONAL JURY, GROUP I.

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IRON AND STEEL.

INTRODUCTION.

1. This report on the iron and steel at the Vienna Exhibition in 1873 was undertaken at the request of the scientific commission of the United States to Vienna, and of the chief commissioner. The materials were gathered and the outline of the report was drawn before leaving Vienna at the close of the exhibition. It was designed to present a review of the iron and steel industry of the globe, but on the author's return to the United States the pressure of other occupation prevented giving that attention to the elaboration of the subject which its importance demands. The data are necessarily presented to a great extent in the form in which they were procured, and without attempts at generalization.

Two or more excellent reports upon the iron and steel at Vienna have been published abroad; one, by Messrs. Maw & Dredge, appears in the reports of the British commission; another, by Anton Kerpely, appears in a separate and private publication, in two parts, at Schemnitz—"*Das Eisen auf der Wiener Weltausstellung.*"

2. According to the figures given by Messrs. Maw & Dredge, the total production of all countries in pig and malleable iron is about 15,322,500 tons annually, divided approximately as follows:

	Tons.
England	6,733,000
United States	2,800,000
Germany	2,664,000
France	1,182,000
Belgium	565,000
Austria-Hungary	425,000
Russia	360,000
Sweden and Norway	306,000
Italy	74,000
Spain	72,000
Switzerland	7,500
British and South America	50,000
Japan	9,000
Asia	40,000
Africa	25,000
Australia	10,000

Mr. David Forbes,* in his report upon the progress of iron and steel industry in the year 1873, gives a total of 14,885,488 tons as a close approximation to the total production of cast iron on the globe. Professor Gruener has since published the following estimate of the total production of cast and wrought iron and steel for the year 1872. He estimates the total produce of steel in the year 1873 as about 1,250,000 tons.

	Cast iron.	Wrought iron.	Steel.
	Tons.	*Tons.*	*Tons.*
England	6, 723, 387	3, 500, 000	500, 000
United States	2, 250, 000	1, 602, 000	143, 000
Germany	1, 600, 000	1, 150, 000	200, 000
France	1, 180, 000	883, 600	138, 000
Belgium	655, 565	502, 577	15, 224
Luxembourg	250, 000	....	....
Austria-Hungary	400, 000	300, 000	49, 250
Sweden and Norway	300, 000	191, 800	12, 000
Russia	360, 000	245, 000	7, 204
Spain	34, 500	35, 600	250
Italy	25, 000	24, 000	....
Canada, India, &c	100, 000	70, 000	....
Total	13, 678, 452	8, 503, 977	1, 064, 988

The secretary of the American Iron and Steel Association, Mr. Swank, adopts the following for the world's production of cast or pig iron:

Countries.	Year.	Gross tons.
Great Britain	1873	6, 566, 451
United States	1873	2, 560, 962
Germany	1872	1, 664, 802
France	1873	1, 381, 000
Belgium	1872	652, 565
Austria with Hungary	1871	424, 606
Russia	1871	354, 000
Sweden	1872	322, 000
Luxembourg	1872	300, 000
Italy	1872	73, 709
Spain	1870	54, 007
Norway	....	20, 000
South America and Mexico	....	15, 000
Canada	....	10, 000
Japan	1871	9, 370
Switzerland	1872	7, 500
Asia	....	40, 000
Africa	....	20, 000
Australasia	....	10, 000
Total	....	14, 485, 972

3. The author's acknowledgments are due to the Messrs. Haswell, of the Austrian State Railway Works, for information regarding the operations of forging under the hydraulic press, and for opportunities of inspecting the process; to Commissioner Danfeldt and Professor Ackerman, of Sweden, and to Dr. Serlo, of Breslau. They are also due, in general, to several of the mining engineers at Vienna, and to the representatives of most of the exhibitors of iron and steel for their courtesy in replying to inquiries, and in furnishing information. The *brochures* de-

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* Bulletin de la Société d'Encouragement, September, 1874, cited by David Forbes.

scriptive of the principal works, which were generally illustrated by maps and drawings, were of great service, and have been freely used in the report. Such publications are important in conveying information to the visitor at the exhibition, but particularly to jurors and reporters. They greatly facilitate the labor of reporting, and save time and trouble to both visitors and exhibitors. Several of the official catalogues were enriched by statistical and descriptive statements, notably those of Sweden and Prussia, by which the value and significance of the exhibition from those countries were greatly enhanced. The utility and educating power of an exhibition is vastly increased by the publication in connection with the catalogues of judiciously-prepared statistical and descriptive summaries of the various industries.

W. P. B.

MILL ROCK, *New Haven, Conn.*

IRON AND STEEL AT THE VIENNA EXPOSITION, 1873.

CHAPTER I.

AUSTRIA-HUNGARY.

General view of the extent of the manufactures and display of iron and steel from Austria and other countries of Middle Europe; Tasteful arrangement of objects; Production of iron and coal in Austria; Development of iron-industry in Carinthia; Sections of furnaces, showing increasing dimensions and increase of product; Dimensions of blast-furnaces in Europe; Interior forms assumed by furnaces after long working; Sections of Mariazell furnaces; Resicza States Railway exhibition; Large Bessemer ingot; Steel samples and rails; Etched iron; Ferro-manganese; Rositzer Mining Company; Rotary puddler, Dank's system; Ehrenwerth's rotating-hearth puddler; Hydraulic forging; Wire-rope traces.

4. Austria-Hungary.—The iron-industry of Austria has advanced rapidly in the last decade. It is prominent at the exhibition, and has never before been so well illustrated by ores and their products, by models, maps, and statistics. The iron and steel production of the empire is referable to three principal groups: (1) The Austrian Alps—Styria, Carinthia, Krain, Tyrol, and Salzburg; (2.) Bohemia, Moravia, and Silesia; and (3) Hungary.

The importation of iron from England and Germany has been greatly lessened, and the exportation of iron and steel has greatly increased. There has of late been a tendency to a consolidation of small and scattered private establishments into large joint-stock associations, with increased capital. The spirit of enterprise and speculation has been aroused and stimulated by the great demand for iron and steel, and by the opening of communication between the mines and coal-fields by rail and between the furnaces and a market for their products. The exhibition happens to be at about the culminating point of many speculative enterprises, and no doubt many are desirous of making the best display possible of the properties upon which these enterprises are based.

The general aspect of the ores is earthy and calcareous, in strong contrast with the ores of Sweden and America. Spathic ore is the rule, and other ores the exception. They are remarkably pure, and very favorable for the manufacture of steel. But it is not sufficient to have this abundance of ores; the fuel is equally necessary, and, unfortunately for the iron-industry of the empire, is not abundant or cheap. Charcoal can no longer be relied upon. The forests are giving out, or are required for other purposes than to be converted into charcoal. The iron-industry is consequently being revolutionized. As in other countries, steel is rapidly taking the place of iron, and the iron-production undergoes great modification from this cause, independently of others.

5. The visitors to the exhibition interested in metallurgical industry are greatly indebted to the forethought of the *Ackerbauministerium* in preparing for distribution a very instructive *résumé* of the mining industries of the empire, and particularly for the historical view of the industries of coal and of iron and of steel in the several provinces.[*] This volume contains a series of descriptive memoirs from such able authorities as Baron v. Beust, the imperial and royal general mining inspector; from Ritter v. Tunner, and from Dusanek, Hofmann, and Rittler. These exhaustive memoirs are really a part of the exhibition, and they justify their liberal use in reporting upon the departments of which they treat. A free and greatly condensed translation of portions of these memoirs has, therefore, been made for the following pages, descriptive of the extent and condition of the iron and steel industry of Austria-Hungary. A few of the preliminary and later statistics are added from the recent report of Prof. David Forbes, received about the time of sending these pages to press.

There were 184 iron-mines worked in Austria in 1872, and 223 in 1873. The number of iron blast-furnaces in operation in 1871 was 115, employing 12,278 workmen; but in 1872, 112 furnaces, with 10,069 workmen. There were 129 works in operation in 1873, and the production is stated as follows:

	Vienna tons.	Value.
Iron-ore	928,982	£408,366
Pig-iron, (foundery)	45,048	459,725
Pig-iron, (forge)	286,236	2,590,133

The production of the mines and works of the Austrian Government Railway, (*Staatsbahn*,) including the collieries at Kladno, in Bohemia, and the machine-works at Vienna, has increased in the eighteen years since the properties came into the possession of the *Staatsbahn*, from (annually) 80,000 to 7,000,000 tons of coal raised; 15,000 to 70,000 tons of iron-ores raised; 7,500 to 35,000 tons pig-iron produced; 6,000 to 27,500 tons wrought iron produced; 25 to 100 locomotives.

The coal-mines of Reschitza yielded 57,800 tons in 1872, a part of which was made into coke. The three blast-furnaces are supplied with charcoal-fuel, and yield gray Bessemer pig-iron from magnetic iron-ore. The yield of these furnaces is about 34 tons of this Bessemer pig in twenty-four hours. A fourth blast-furnace at Bogsan produces about 5,000 tons of pig-iron annually. The iron at Reschitza is run directly from the blast-furnaces into the Bessemer converters, which are nine tons' capacity and three in number. The annual production is about 9,000 tons.

---

[*] Denkbuch des Österreichischen Berg- und Hüttenwesens. Aus Anlass der Wiener Weltausstellung herausgegeben vom K. K. Ackerbauministerium, unter der Redaction des Ministerialrathes Anton Schauenstein. Wien, Verlag des K. K. Ackerbauministerimus, 1873. 8vo. pp. 370.

There are 17 puddling-furnaces and 30 furnaces for reheating and welding. There are 10 trains of rolls. The production in 1872 amounted to 12,550 tons of finished products, 7,810 tons being plates and rails, and 4,669½ tons Bessemer steel, in the form of axles, tires, rails, plates, &c.

6. As might be expected, Austria-Hungary takes the lead in this exhibition in the extent and variety of the display of iron and steel. It is at first bewildering to the visitor. He roams from one pavilion to another, seeing in each a museum of metallurgy, a mine of instruction. It is more than can be grasped in several visits, and requires repeated examinations and time for review and comparisons.

This exhibition of iron and steel from Austria and Middle Europe, being by far too extensive and bulky to be received in the main industry palace or in the courts of the building, was placed for the most part in a series of separate buildings between the machine hall and the palace. Belgium alone makes most of its display in the main building. Austria and Prussia each have separate and special buildings for displaying the products of mining industry. For Austria there are three or four buildings, of which Carinthia alone fills one, and Styria another. The State Railway Company and other wealthy corporations have exhibitions of their own.

The Prussian miners and manufacturers of iron fill the greater portion of two large buildings, one on each side of Krupp's central pavilion, erected exclusively for his remarkable collection. On entering one of these buildings, devoted to mining and quarrying, the miner feels more than ever a just pride in his vocation. He sees the miner's arms, the crossed hammers, conspicuously emblazoned in gold over the doors, and underneath the familiar motto, "*Glück auf*," "Good luck to you," and within, inscribed upon the walls, such sentiments as, "*Gott schütze das Vaterland und segne den Bergbau.*" Here, truly, the typical honest miners are to be found. The government honors their calling, and ranks it with agriculture, as at the foundation of national prosperity. But for the organized mining-systems of Europe, such a magnificent exhibition in the group of mining and quarrying could hardly have been made. As it stands to-day, it is an honor to the art, a fair child of science and industry.

The attention of every visitor is at once arrested not only by the wealth of the display in every branch of the industry of iron and of steel, but by the skill and taste shown in the arrangement of the objects. Railway wheels and axles produce little effect when tumbled loosely upon the floor; but if they are grouped in monumental masses, or are supported high in the air by light but strong steel bands, they provoke interest and admiration, even in those who know nothing of their excellencies or defects. In all of these buildings devoted to mining and metallurgy, a liberal and generous spirit, worthy of the true miner, is shown in the provision of chairs and tables for the use of visitors, so that they may consult books of reference, or take notes at their ease. Maps and diagrams on the walls explain the position of the mines, the geology, and the method of working them. The more important of the Austrian mines are illustrated by models, showing the topography, the surface-construction, and the geological structure of the deposits, while by means of machinery part after part can be lifted off, and the whole interior of the mine displayed. The ores are sent in quantity enough to form pyramids outside of the buildings, in addition to the systematic collections within. Iron is shown in all its stages of manufacture, and the more direct manufactured products, such as rails, tires, girders, boiler-plates, &c., are exhibited in profusion. It is impossible to describe such collections, or to give an adequate idea of their value. They are complete museums of the industry, such as any mining institution in the world would be glad to take and preserve intact.

Austria-Hungary has of late years made great strides in the extent of production of iron and steel, and in the quality of the product. The importations from England and Germany are considerably lessened, and the exportations are increasing.

7. IRON AND STEEL PRODUCTION.—The iron-ores of Austria are principally spathic (the carbonate of iron) and the deposits are very extensive and easily worked. The celebrated ore-mountain has beds from 20 to 40 feet thick, containing from 20 to 50 per cent. of iron, and has been worked for a thousand years without any signs of exhaustion. With such ores, and charcoal for fuel, there is no difficulty in producing a very fine quality of iron and of steel. Brown coal or lignite is largely used, and a coke made from turf is the fuel in some places. In the display made by the State Railway Company there is a complete section of a coal-seam 14 feet thick; so that, in some districts at least, there seems to be no scarcity of mineral fuel. In the charcoal-districts the great care of the forests by the government prevents their complete extinction, and with them the dependent iron-furnaces, as would be the case under the reckless policy pursued in the United States.

The production of iron-ore in the Austrian Empire has steadily increased from a total of 655,970 tons in 1867 to 1,067,753 tons in 1871. To this may be added 432,700 tons for Hungary, giving a grand total of 1,482,000 tons. The total product of pig-iron for the same year was 8,200,000 centners. The production of Bessemer steel is also rapidly increasing.

8. THE IRON AND STEEL INDUSTRY OF THE AUSTRIAN ALPINE REGION.—The iron and steel industries of this part of Austria are found in the provinces below the river Enns, Styria, Carinthia, Krain, Tyrol, and Salzburg. Nineteen-twentieths of the ore mined is spathic ore, which, when roasted, yields 50 per cent. or more of pig-iron. The production has increased in some of the provinces and decreased in others, as will

be seen by the following tabular statement of the product at three decennial periods, with the cost per hundred-weight at the mouths of the mines:

Location of mines.	Production of iron-ores during the year—			Average cost-price of one hundred-weight at the mouths of the pits.
	1851.	1861.	1871.	
	Centners.	*Centners.*	*Centners.*	*Kreutzer.*
Austria, below river Enns	175, 150	195, 560	141, 380	32. 5
Styria	3, 221, 240	3, 876, 000	7, 537, 330	15. 0
Carinthia	1, 712, 490	2, 135, 600	3, 252, 700	20. 0
Krain	251, 930	350, 000	203, 160	37. 5
Tyrol	248, 550	271, 560	176, 860	36. 0
Salzburg	308, 040	220, 270	120, 710	18. 0
Total	5, 917, 400	7, 048, 990	11, 432, 140	18. 4

The above table shows that in 1871 the joint produce of the six provinces was nearly double the amount produced in 1851. During the last few years especially this increase has been marked. The reason of this lies not only in the increased demand for iron and in the enormous rise in its price, but the principal cause is the adoption of mineral fuel in the furnaces. The exclusive use of vegetable fuel in the Alpine region is the only reason for the non-increase of iron produce in several of the provinces and the failure to satisfy the home demand. All regions that have adhered to the vegetable fuel labor under the same difficulties. It is, therefore, Styria and Carinthia only which show an increased product and which supply the increased demand for iron in the above-mentioned provinces.

Styria and Carinthia possess two most important iron-mines—Eisenberg and Hüttenberg.* These two localities, in quality and quantity of ores, are equaled by few and surpassed by none of the other European mines. They have already been worked, according to the most authentic researches, almost two thousand years; and there is every reason to believe that the increased demand for iron will not exhaust their capacity in a thousand years to come. The raw material of the Erzberg is mostly quite accessible, and the quantity is estimated at 2,500,000,000 to 3,000,000,000 hundred-weight; that of the Hüttenberg a little less.

The celebrated Eisenberg, or ore-mountain, is well represented by a model, upon a scale of one-twentieth, made by Professor Allgayer in Leoben, and exhibited in the building of the Inneberger Company. The ore crops upon the side and summit of the mountain, and forms the greater portion of its mass upon one side. The beds of ore are interstratified with limestone and *grauwacke* overlying black slate, and are from 20 to 40 feet thick in the aggregate. A portion, mixed with lime-fuel was erected by C. von Scheuchenstuel, in St. Stefan, near Leoben. From year to year the statistics show an increase in the numbers, so that in Austria, excepting Hungary, there existed 23 puddling-works, having 63 puddling and 36 welding furnaces. In 1851, there were 41 puddling-works, with 114 puddling and 76 welding furnaces, and 122 rolling-mills. The total produce of these 41 puddling-works amounted, in 1857, to only three quarters of a million centners raw material, making about 150 to 160 centners per furnace per week. Influenced by the great variety and expense of the fuels, the puddling and welding processes in the Austrian Alpine regions have attained a great variety of forms, many improvements having been introduced to secure the greatest possible economy in fuel.

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* For the statistics and history of these mines, see Muchan's History of Styria.

In 1842, gas-welding furnaces using brown-coal slack as fuel were introduced. The erection of wood-gas puddling-furnaces in 1844–'45, at Lippitzbach, in Carinthia, created quite a sensation by the favorable results attained, (3 to 4 cubic feet of wood to 100 pounds puddled iron.) Turf-puddling commenced in 1842, at Buchscheiden, in Freudenberg, and at Rottenmann, and was imitated by several minor works in Tyrol, Salzburg, and Carinthia. The step-grate for using the poor brown coal of the Alps was introduced in Prävali in 1850. The Swedish gas-puddling furnaces were introduced in Eibiswalde in 1858–'59, the fuel being a mixture of brown coal and wood.

Siemens furnaces have been introduced with great advantage. They are in general use for welding, but are only occasionally met in puddling-works, for the reason that the exhaust heat of the waste gas is used for raising steam. The double furnaces are largely in use in Carinthia, but in Styria the single ones are preferred on account of less expenditure in wages, and the better quality of the product. Hydraulic motors have been replaced by steam-power in most of the puddling-works. Upright and horizontal boilers are used, ranging from 25 to 30 horse-power. The first large steam-hammer was erected at Neuberg in 1852; it was of the Condies design, and gave a 100 hundred-weight blow. Then followed the introduction of several Nasmyth hammers with from 85 to 200 hundred-weight blows. The largest steam-hammer of the region was erected in 1865 at Neuberg, the weight of the blow being 350 hundred-weight. In 1859 the first hydraulic forge-press was erected at the Donawitz works. It has a maximum pressure of 15,000 hundred-weight.

In the wire-manufacture, which is very extensive on account of the excellence of the raw material, the factories of St. Egydi, in Upper Austria, of Feistritz, in Carinthia, and of Thörl, in Styria, should be mentioned on acount of the quality and quantity of material turned out. The tin-plate manufacture has attained considerable prominence in Wollersdorf, in Austria, below the Enns, and especially in Passhammer, in Styria. The produce of these two factories amounted in 1870 to 42,280 centners, being 23,190 centners of tin-plate, 16,140 centners of black plate, and 2,950 centners of zinked iron. Other factories of the same description have been erected since then in Ludenberg and Trieben.

A number of puddling and rolling works exist in Styria and Carinthia, producing annually more than 200,000 hundred weight of iron. Most of these works are well fitted up and in the hands of companies and associations. A pleasing fact relative to these works is that all the operatives, from the managers and engineers down to the lowest workmen, are natives of the provinces, showing thereby that the industry has taken firm root, and that a successful opposition to foreign trade could be carried on if pig-iron can be produced in sufficient quantities and at a price low enough to compete with the imported.

11. *Rod and bar iron.*—The direct method of producing bar-iron from the ores has, till within a short period, been adhered to by several of the minor smelting-works in the Alpine countries; but now they first produce the pig-iron, and from this make bar-iron by puddling.

Bloomaries or forges were formerly numerous throughout the Alps, but the increased price of charcoal and the almost exclusive use of it in blast-furnaces have considerably reduced the proportion of bar-iron produced in this way. The first puddling-furnace in Carinthia was erected in 1828, and in 1851 the ratio of puddling-furnaces to bloomaries was as 2 to 1. In 1861 the bloomaries were reduced to one-half, and in Styria in 1871, out of the formerly legally-licensed 271 bloomaries only 100 to 110 remained, producing about 33 per cent. of the bar-iron of Styria. A great number are now totally extinct, and only those furnaces working the Lancashire method, and producing wire and fine tin-plate, are still existing. A limited number of bloomaries favored by local fuel will, of course, continue to exist. Such works are generally far removed from other furnaces, and are confined to one or two specialties.

12. *Steel in the Alpine regions of Austria.*—The spathic ores of Austria are so favorable for steel-manufacture that they are often named "steel-ores." This adaptation of the ores is the reason that as long as open-hearth steel predominated in the steel-market, the Alpine provinces, Styria, Carinthia, Krain, and Tyrol, ranked first in the steel-production. Thirty or forty years ago the production of steel in the Alpine provinces of Austria amounted to 300,000 centners, of which a great part was exported to the East and America via Trieste, and some to Germany, France, and Switzerland, leaving to the exporters a handsome profit. The produce of these provinces at present hardly ampunts to 30,000 centners, and is steadily decreasing, owing to the scarcity and cost of charcoal. The first puddled steel was made in Frantschack, in 1835, by Messrs. Schlegel and Müller, who took out a patent for their method. But the real production of puddled steel in Austria dates from 1852, at the foundation of the Eibiswald and Neuberg works. This method is largely in use at the present time, and, by its cheapness, has driven the

open-hearth steel almost entirely from the market. Puddled steel is at present refined to all the different kinds of steel (Brescian, Gerb, scythe, and damask steel) formerly produced from open-hearth steel. The production of tires and railroad-iron increased the make of puddled steel, but the Bessemer and Martin processes have now superseded it. The largest steel-puddling works are those of Streitben. The introduction of puddled steel has largely increased the steel-production of Austria, but not in the same ratio as in other countries, especially in Germany. The immense advantage possessed by Austria in the excellence of her raw material, so well suited for steel-production, is more than balanced by the cheapness of labor and fuel of her German competitors, especially the Westphalian manufacturers. It is only the decided superiority of the steel which gives the Carinthian product a hold upon the market against the much cheaper Westphalian puddled steel.

Cement-steel.—The demand for a suitable steel for springs of railroad carriages, for which the cement-steel is best adapted and cheapest, stimulated the erection of works of this description in Eibiswald, and soon after in Donawitz, near Leoben. The results were satisfactory. The annual production of Donawitz amounts to 25,000 centners spring and saw blades. But in proportion to the use of puddled steel, that of cement-steel is very limited.

The *glühstahl* (welded steel) is a similar product, which is now made at Donawitz. This steel was exhibited in London in 1851, and again in Munich in 1854,* by F. Lohmann, of Witten, Westphalia.

Since 1854 there has been an annual produce of 5,000 to 6,000 centners of this variety in Donawitz. A cement-furnace for the manufacture of welded steel was erected in 1871 in Reichraming.

13. *Cast steel.*—The manufacture of crucible cast steel has long been established in the Alpine provinces; but as the old English method of manufacture, by draught-furnaces, required an immense quantity of charcoal, often as much as 50 cubic feet per centner of steel, the production has naturally been kept down. In 1851 the total production of cast steel in Austria amounted to a little more than 8,000 centners. Immense progress was effected in 1858 by introducing the Siemens furnaces in Kapfenberg. These works commenced with furnaces of 8 crucibles, each holding a charge of 45 pounds, and using 400 pounds Leoben brown-coal slack per 100 pounds steel. At present (1873) there are 10 Siemens furnaces of 18 to 20 crucibles in use. The charge is still 45 pounds to each crucible, but the consumption of fuel is reduced to 250 pounds brown-coal slack. The annual production of these works is 30,000 centners. This steel, mostly soft-tempered, is used for gun-barrels, and is partly exported to Germany. It is no longer a secret that the raw material used to produce crucible steel is regulated according

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* Described by Peter v. Tunner in his book "*Der Wohlunterrichtete Hammer meister,* Graz, 1846, p. 424.

to the degree of hardness of the steel required. It consists in mixing bar and spiegel iron, (ferro-manganese.)

The inventor of this method is Alvis Obersteiner of Murau.* He has used this mixture in Austria as far back as the year 1825, and received a patent for it. From the small, unimportant iron-works of Murau it was transported to Westphalia, and from thence to Essen, forming the basis of Mr. Krupp's immense success and giant works.

A specialty of the Austrian cast steel is the "silver-steel" of Mr. Müller's works in St. Egydy, widely known, likewise, for the production of steel strings for piano-fortes.

The manufacture of Wolfram steel has been everywhere abandoned, on account of the easy oxidation of the Wolfram.

The whole production of crucible cast steel in 1871, in Austria, amounted to 85,000 centners, from 18 different smelting-works, and has, therefore, been augmented tenfold in the last twenty years. This increase would have been still greater but for the Bessemer-steel production.

14. *Bessemer steel.*—The first Bessemer-steel in Austria, and (except a few unimportant trials made in several places) the first of the continent, was produced in 1862, at Turrack, in Styria. Other works soon followed in Heft, in Carinthia, in 1864. In 1865 the works of Neuberg were opened. The production of the existing Bessemer works in the southern portion of the Alpine provinces is shown by the annexed table:

Production of Bessemer steel in Austria.

Name of Bessemer work.	Number of converters.	Annual production.			Estimated amount of present produce.	Percentage of net produce.	
		1869.	1870.	1871.		Total.	Clean ingots.
Styria:		*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*		
Turrack	3	9,270	12,153	22,800	50,000	90.1	83.5
Neuberg	2	62,250	79,598	105,230	120,000	89.0	87.0
Graf	2	63,325	77,563	91,538	....	85.5	84.5
Zeltweg, (since 1871 in use)	2	....	....	30,000	250,000	......	......
Carinthia:							
Heft	2	24,551	15,276	62,051	100,000	......	84.0
Austria below the Enns:							
Ternitz: Since July 1	2	106,284	178,985	386,896	720,000	89.7	88.4
Middle of 1871	4						
Middle of 1872	6						
Total	......	365,680	363,575	698,515	1,240,000	......	......

To be added to this is the production of Reschitza, in Hungary, in 1871, 125,000 centners, and Witkowitz, in Moravia, 65,566 centners, which gives for the total produce of 1871, 889,231 centners. It is much in favor of the Bessemer method that the production of puddled steel in Austria and Hungary from 1826 to 1851 (twenty-five years) amounted annually only to about three-quarters of a million centners, while the product of Bessemer steel in eight years attained the annual figure of 889,231 centners. This is still more strikingly shown by the statistics of Styria, which show that the produce of puddled steel in 1851 amounted to about 200,000 centners, while the Bessemer product in 1871 reached 250,000 centners, and may be calculated for 1872 at 400,000 centners. The charge in the different Bessemer works varies between 100 and 50 centners, and the average charge may be put down at 70 centners,

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* See Vordernberger Jahrbuch. 2 band. Graz, 1843.

15. *Martin steel.*—The manufacture of Martin steel was commenced in 1867, in Kapfenberg, under the direct superintendence of Mr. Martin, who made the drawings for the furnaces, and supplied the workmen. This trial showed that the resulting steel was better in quality than the crucible cast steel, and that it cost less. In 1869 immense works were erected in Florisdorf, near Vienna, by Messrs. Barber & Klusemann, the patentees for Austria. These works contained 5 smelting and 3 welding furnaces, with 32 distant and 4 close gas-generators, and likewise with 11 Siemens furnaces. Martin's process is also used in Gratz and Neuberg. The charges average about 60 centners, consisting of 25 per cent. gray pig-iron, 70 per cent. bar-iron and steel scraps, and 5 per cent. spiegel iron and waste. The consumption of fuel is 80 to 100 pounds coal, or 140 to 160 pounds of brown coal, per centner of steel. The produce of the Martin's works of Gratz, in 1871, was as follows: Charges of iron, 3,205,285 centners, which produced 3,019,774 centners of steel, with a waste of 52,515 centners. The pure steel produced amounted, therefore, to 94.21 per cent., the waste to 5.79 per cent. The Martin works, in Neuberg, produced in 1871 14,368 centners of steel ingots, with a loss in raw material of 9.8 per cent., and a waste of 1.7 per cent.

16. EXTENT OF THE IRON-INDUSTRY IN BOHEMIA, MORAVIA, AND SILESIA.—Iron-mining in Bohemia dates back in the remote past beyond the records of history. It is mentioned in lays and traditions as early as 677 years before Christ, and the historian Hajeck locates these early works in the vicinity of Caslaw. Many of the names of Bohemian towns are derived from the ancient mining localities. Iron-smelting was formerly carried on by Bohemian proprietors to utilize the otherwise valueless tracts of timber covering the country; but the far-spreading extensions of railroads have recently given so high a value to building-timber that iron-smelting works are forced to employ a cheaper fuel. Moravia was in advance of Bohemia in changing from charcoal to a mixture of wood and coke. Although the veins of brown coal in Bohemia are almost inexhaustible, there is still an acknowledged want of suitable coals for smelting purposes. There soon (1872–'73) will be thirteen furnaces using coke in full working order in Bohemia. They will consume at the minimum calculation 5,000,000 centners of coke to produce the same effect as 12,500,000 centners of coal. The coals of Schadowitz are the most suitable for smelting purposes. The Miroschau coals, on account of their brittleness, are neither suitable nor profitable for use in furnaces. Under these circumstances, the iron-works in Bohemia using coke will always have to rely upon a foreign supply of fuel. The Moravian iron-works are differently situated. The coal-fields of Ostran insure

an ample supply of coke-producing coal; but rich iron-ore veins are scarce. The difficulties in the rapid development of smelting-works using coke in Bohemia, Moravia, and Silesia are very formidable, but the iron-masters are determined to overcome them and to maintain the success of the iron-industry.

17. ***Iron-ore Mining.***—In the year 1807 there existed in Bohemia 46 furnaces in full working order, producing 1,040 hundred weight of iron in twenty-four hours.

The following table shows the amount of iron-ores produced during 1870:

Production of iron-ores during the year 1870.

Country.	Production.	Number of mines.	Number of workmen employed.	Average price at the works.	Total value.
	Cwt.			*Florins.*	*Florins.*
Bohemia	4,581,582	49	1,877	15.3	563,703
Moravia	1,788,075	18	1,464	13.0	234,406
Silesia	296,318	6	630	26.3	45,926
Total	6,665,975	73	3,971	....	844,035

Out of these 73 iron-works, 2 did not yield any profits and 15 suspended operations. Their joint production of iron-ores amounted to 40 per cent. of the entire produce of Austria.

About the year 1865, the product increased in Bohemia 2,184,486 centners, and in Moravia to 381,379 centners, but diminished in Silesia 66,977 centners, showing a total increase of 2,498,888 centners in the three countries. Sixty per cent. of the iron-ore comes from the Silurian districts, and the amount carried out of Bohemia forms 90 per cent. of the entire produce of that country. The principal proprietors of the iron-mines are the "Præger Eisenindustrie Gesellschaft," the Lebrow estate, the elector of Hesse-Cassel, the Prince Colloredo Metternich, and Prince Furstenberg and the State of Pilsen. The greatest mines are those of Nucier. The Chamoisit mines are worked by the aforesaid company, and the product is taken through horizontal tunnels to the Nucier Railroad. Below the level of the tunnels the transportation of the ore is difficult and expensive. The red-ironstone mines are comprised in two divisions. The eastern one embraces the Karabina Mountains, and the veins of Swarover on the left bank of the Kacier brook. The western division is formed by the mines of Jezovcin Chrbina, on the right bank of the little river Raciba. The eastern division is known under the name of Suarow works, the western as Chrbina mines. In Suarow the veins are perpendicular, in Chrbina they are horizontal. The average cost-price in the two principal works is as follows: Chrustenic, 1 hundred-weight of iron-ore, 15½ to 17 kreutzer; Krahulov, 1 hundred-weight of iron-ore, 22½ to 23½ kreutzer. The total produce of iron-ore from the mines of the Elector of Hesse-Cassel, in the year 1870, amounted to 371,190 hundred-weight, and the average cost per hundred-weight amounted to 10.9 kreutzer. All the iron-mines of Bohemia are worked on the most approved scientific principles. In minor works the water is taken out either by windlass or by bucket, but in the more important ones pumps are employed, moved either by steam or water power. In Moravia, in most cases, the mines are a long distance from the smelting-works, and often the transportation is difficult and insufficient. The cost-price of the product therefore varies considerably. In a total production of 9,473,374 hundred-weight the price, at the mouth of the pit, ranges from 7½ to 10 kreutzer (minimum) to 18 to 19 kreutzer, (maximum.) The transportation to the smelting-works increases these prices from a minimum of 19 up to 65 kreutzer.

The ores of Silesia are mostly magnetic, red, brown, and spathic ironstones, and specular iron, yielding 23 to 27 per cent. The large ironworks of the Archduke Albrecht of Austria cover a surface of 1,229,312 square klafters, and their produce in the year 1871 amounted to 188,730 centners. The average cost-price amounted to 37 kreutzer per centner. Some of the ores were very poor, containing only 18 to 24 per cent. of iron.

18. *Production of pig-iron.*—The following table gives the quantity of pig-iron produced in the three countries during the year 1870:

Country.	Raw iron.		Total.	Number of furnaces.			
	Bloom.	Cast.		Not working.	Working.	Total.	Working weeks.
	*Centners.**	*Centners.*	*Centners.*				*Number.*
Bohemia	953, 433	320, 476	1, 273, 920	12	40	52	1, 727
Moravia	410, 611	186, 221	596, 832	....	21	21	874
Silesia	65, 910	51, 974	117, 885	1	6	7	293
Total	1, 429, 954	558, 671	1, 988, 637	13	67	80	2, 894

* Or one hundred-weight.

The production of pig-iron was, until the year 1838, effected throughout the whole of Bohemia by means of charcoal-furnaces. From this period the use of coal-fuel commenced, and a constant changing of old furnaces and adding of new ones has been going on ever since.

The cost of producing 100 pounds of pig-iron in the Silurian districts may be stated as follows:

	Fl.	Kr.
330 pounds of ore, at 20 kreutzer	0	66
45 pounds of limestone	0	2
16 cubic feet of charcoal, at 15 kreutzer	2	40
Wages	0	20
General working-expenses	0	25
Total	3	53

The steady advance in the prices of charcoal will, in the future, increase the cost of the raw material.

19. *Founderies.*—In Bohemia, casting is generally done directly from the furnaces, and the largest portion is common commercial castings. The most important foundery of Bohemia is that of Kladno, which produces the most complicated and heaviest machinery-castings. The founderies of Moravia are almost entirely employed in machinery-casting. Several works use cupolas with hot-blast. The most important foundery, that of Blansko, turns out annually 150,000 centners of castings.

The Silesian founderies are on the same principle as the Moravian, and their annual produce is about 60,000 hundred-weight of castings. The founderies of Adamsthal work up annually 46,000 hundred-weight of raw material, consuming fuel as follows: Coke, 18,000 hundred-weight coal, (Ostran,) 12,000 hundred-weight; charcoal, 24,000 cubic feet.

20. *Rolling-works.*—(1.) The wörks of the *Præger Eisenindustrie Gesellschaft.* These works are in Kladno, Nürschau, Wilkischen, and Josephihütte. The annual production is 700,000 centners.

(2.) Baron von Rothschilds's works at Witkowitz. The produce, mostly railroad-iron, tires and axles, sheet-iron and commercial iron, is 400,000 centners per annum.

(3.) The works of Archduke Albrecht at Karlshütte and Ustron produce 320,000 centners per annum.

(4.) Rolling-works of Prince Fürstenberg in Althütten, near Beraun and Bras, Rostok, in Silesia, and Purgletz, in Bohemia, with a joint produce of 290,000 centners per annum.

(5.) Iron-works of the Klein Brothers in Töptan and Stefanau, producing 200,000 centners annually of beams, girders, boiler-iron, and steel.

(6.) The white-iron works of Neudeck produce 80,000 centners per annum.

(7.) Mr. Bondy's works at Bubna, near Prague, produce 70,000 hundred-weight per annum.

(8.) Count Harrach's establishments. The production amounts to 28,000 centners of tin-plate, 18,000 centners of drawn wire and light bar-iron.

(9.) Two works of an unimportant character are in process of erection at Komotan and Leibnitz. Besides these large establishments, there are several smaller ones.

21. *Bloomaries and puddling-works.*—The manufacture of wrought iron was, up to the year 1865, an important branch of the Bohemian iron-industry, and there were then in operation 110 bloomaries and 28 blast-furnaces, producing more than 250,000 hundred-weight per annum. The production of Moravia failed to come up to this standard, and in 1865 it amounted to 120,000 hundred-weight. Silesia, with 28 bloomaries and 10 blast-furnaces, produced about 50,000 hundred-weight, so that the total production of the three countries during the year 1865 amounted to 420,000 hundred-weight. But since this period most of the Bohemian bloomaries ceased to work, and in 1870 only a few were in active operation, and these worked only

to utilize the remnants and scrap-iron of their founderies and rolling-mills. Most of the charcoal-furnaces possessed two to four bloomaries, which partly refined the pig-iron but never converted it into wrought iron. At the present time only those bloomaries are of any importance which produce raw material for rolling-mills, especially if the object is to produce a good quality of iron from scraps and remnants. In the year 1871 there were 116 puddling-furnaces in Bohemia, and 70 in Moravia and Silesia, making a total of 186 puddling-furnaces. The pig-iron produced in Bohemia, Moravia, and Silesia, and the remnants and scraps of rolling-mills, do not satisfy the demand of the puddling-works for raw material, so that over 2,500,000 hundred-weight of pig-iron is annually imported. In all the new works each furnace is supplied with a separate chimney. Double furnaces are only employed for the manufacture of inferior kinds of iron. The "loupes" are compressed by steam-hammers on the Nasmith principle. The works are fitted up with two pairs of rollers, but those erected during the last five years have generally three rollers placed one above the other.

The producing capacity and the consumption of material differ vastly on account of the different kinds of coal employed. The annexed table shows the results, employing Ostran coals, in the manufacture of an average quality of iron per 100 pounds rails:

Consumption of pig-iron: single furnace, 114 pounds; double furnace, 114 pounds. Consumption of coal: single furnace, 135 pounds; double furnace, 95 pounds. Weekly capacity of production: single furnace, 270 hundred-weight; double furnace, 400 hundred-weight.

22. DEVELOPMENT OF IRON-INDUSTRY IN CARINTHIA.—Among the many interesting special publications to accompany the exhibits at Vienna, the memoir of Friedrich Münichsdorfer upon the production of iron in Carinthia* is deserving of special mention. Besides a general history of the development of the iron-industry since the time of King Otto in the year 953, it gives an account of the prices of iron during the century, a tabular statement of the production for the last fifty years, and a comparison of existing furnaces with those of the beginning of this century, as respects form, capacity, extent, and economy of production. This comparison is rendered striking and instructive by a series of vertical sections of the furnaces at different periods, drawn to the same scale, presenting a complete view of the gradual development of furnaces, from the simplest form in early times to the modern furnace, with its comparatively enormous product.

During the construction of a railway a few years since, some ancient smelting-hearths, dating back to the time of the Romans, were uncovered. They consist of holes or ditches depressed below the surface of the ground and lined with fire-clay and quartz to a thickness o some 18 inches.

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* Geschichtliche Entwicklung der Roheisen-Produktion in Kärnten, zusammengestellt von Friedrich Münichsdorfer, Oberbergverwalter in Hüttenberg. Klagenfurt 1873. Pp. 36, and 14 plates.

Blast-furnaces from 5 to 6 feet high were introduced in the eighth century. They were so placed as to have a natural draught or blast. The "wolf" furnaces had a rectangular base of 4 or 5 feet, and a height of from 6 to 8 feet. A furnace of this kind at Sölling, in 1775, was elliptical in section and 12 feet high. The iron bloom was removed from the front.

23. SECTIONS OF CARINTHIAN FURNACES.—The sections which follow show the constantly-increasing dimensions of the furnaces and the economy of production. In the following descriptions of the Carinthian furnaces the numbers of the notes at the foot refer as below:

1. Kind and mixture of ore.
2. Blast.
3. Tuyeres.
4. Average production in twenty-four hours.
5. Consumption of coal per Vienna centner of pig-iron in cubic feet.
6. Per cent. of production.

The name of the furnace and the date are placed at the head.

KREMSBRUCKEN.

Last campaign, 1833.

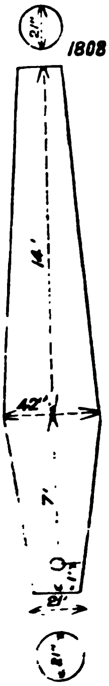

FIG. 1.

1. Brown iron-ore and ocher.
2. Two box-bellows.
3. One tuyere.
4. 62 Vienna centners.
5. 20.6 cubic feet.
6. 36 per cent.

EISENTRATTEN.

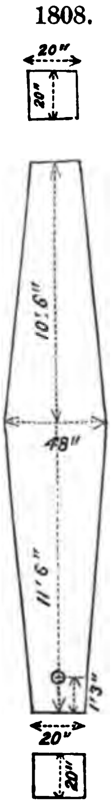

Fig. 2.

1. Brown iron-ore and ocher.
2. Four box-bellows.
3. Two tuyeres.
4. 95 Vienna centners.
5. 23.2 cubic feet.
6. 38 per cent.

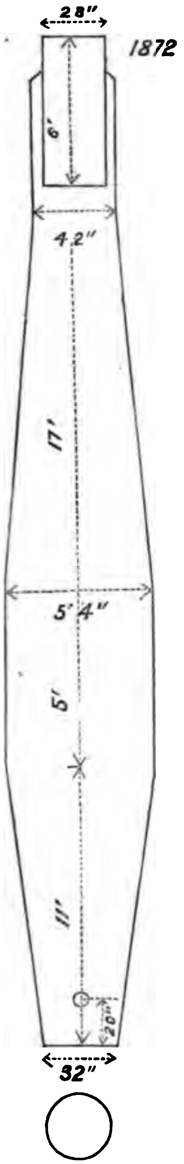

Fig. 3.

1. Brown iron-ore and ocher.
2. Three cylinders.
3. Three tuyeres.
4. 118 Vienna centners.
5. 16 cubic feet.
6. 37 per cent.

RADENTHEIN.

Last campaign, 1863.

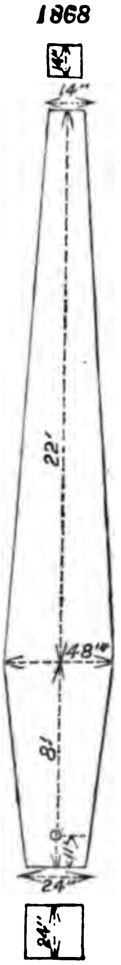

FIG. 4.

1. Magnetic iron-ore.
2. Two box-bellows.
. One.
4. 25 Vienna centners.
5. 20.3 cubic feet.
6. 30 per cent.

DEUTSCH-PONTAFEL.

Last campaign, 1847.

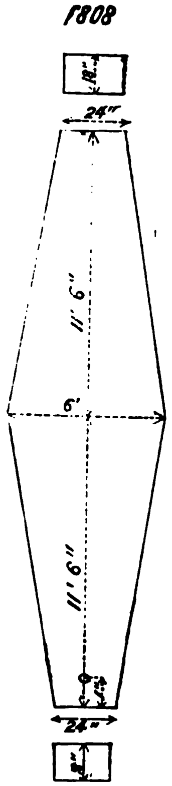

FIG. 5.

1. Red and brown iron-ore.
2. Three water-strommels.
3. One.
4. 45 Vienna centners.
5. 25.3 cubic feet.
6. 46 per cent.

ST. SALVATOR.

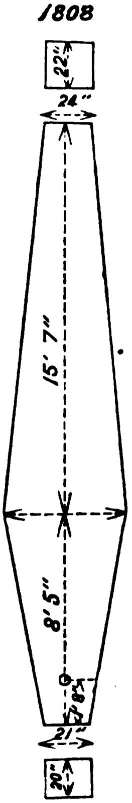

FIG. 6.

1. Brown iron-ore and spathic ore.
2. Two box-bellows.
3. One.
4. 71 Vienna centners.
5. 18.6 cubic feet.
6. 40 per cent.

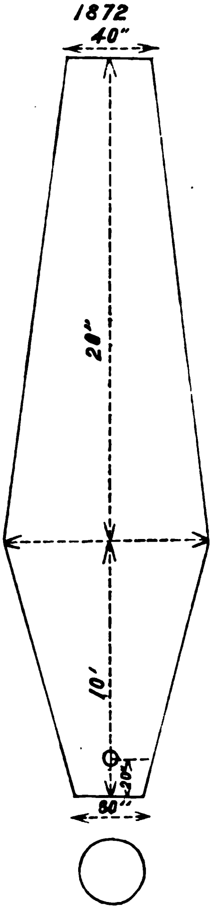

FIG. 7.

1. Brown iron-ore.
2. Three box-bellows.
3. Two.
4. 120 Vienna centners.
5. 16 cubic feet.
6. 40 per cent.

HIRT.

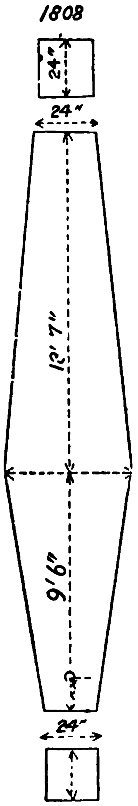

FIG. 8.

1. Brown ore and spathic ore.
2. Two box-bellows.
3. One.
4. 59 Vienna centners.
5. 16.7 cubic feet.
6. 36 per cent.

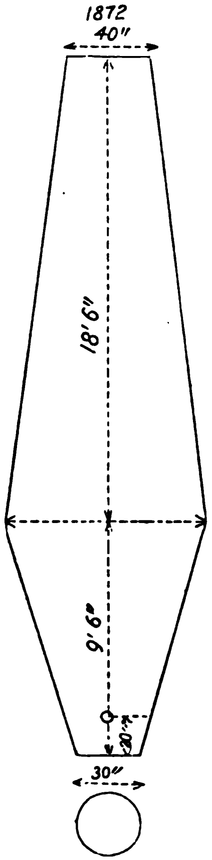

FIG. 9.

1. Brown ore and spathic ore.
2. Cylinders.
3. Two.
4. 130 Vienna centners.
5. 12 cubic feet.
6. 46 per cent.

OLSA.

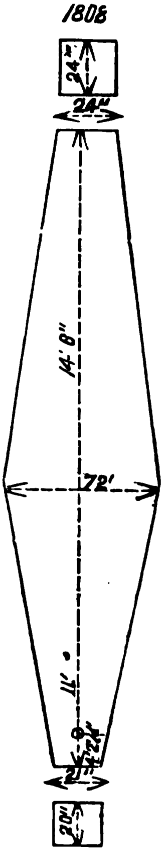

Fig. 10.

1. 4-5 brown iron-ore, 1-5 spathic.
2. Two box-bellows.
3. One.
4. 75 Vienna centners.
5. 15.9 cubic feet.
6. 36 per cent.

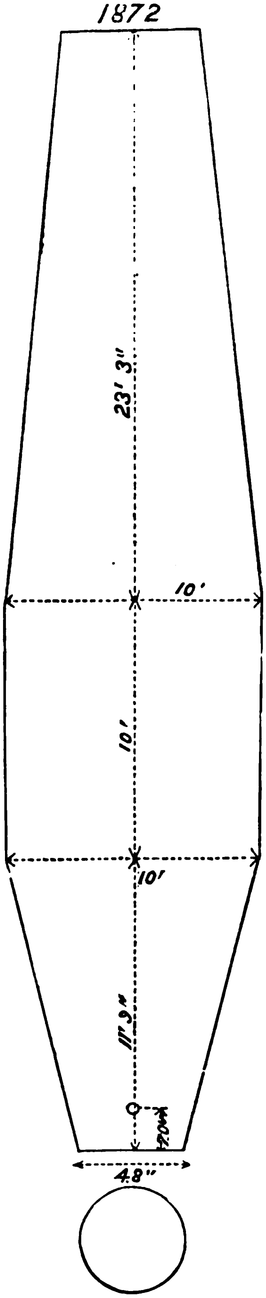

Fig. 11.

1. Brown iron-ore.
2. Three cylinders.
3. Four.
4. 275 Vienna centners.
5. 11 cubic feet.
6. 36 per cent.

FEISTRITZ.

Last campaign, 1834.

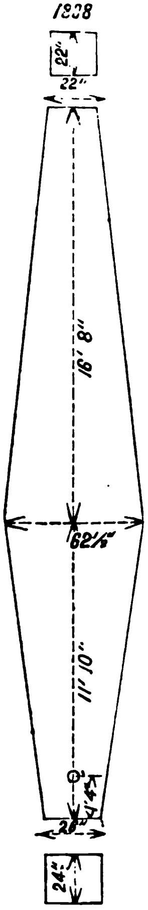

Fig. 12.

1. Brown and spathic ore.
2. Two "spitzbalge."
3. One.
4. 80 Vienna centners.
5. 10.3 cubic feet.
6. 45 per cent.

TREIBACH.

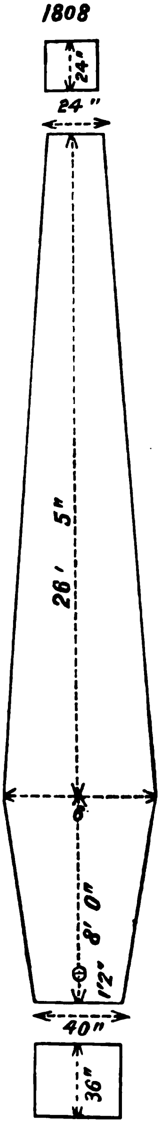

FIG. 13.

1. Brown ore and spathic.
2. Four box-bellows.
3. Three.
4. 160 Vienna centners.
5. 12.2 cubic feet.
6. 46 per cent.

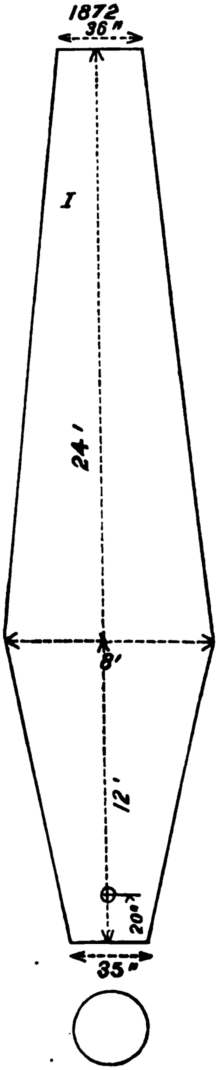

FIG. 14.

1. 91 per cent. of brown ore and 9 per cent. of spathic ore.
2. Four cylinders.
3. Three.
4. 278 Vienna centners.
5. 10.48 cubic feet.
6. 46 per cent.

1872.

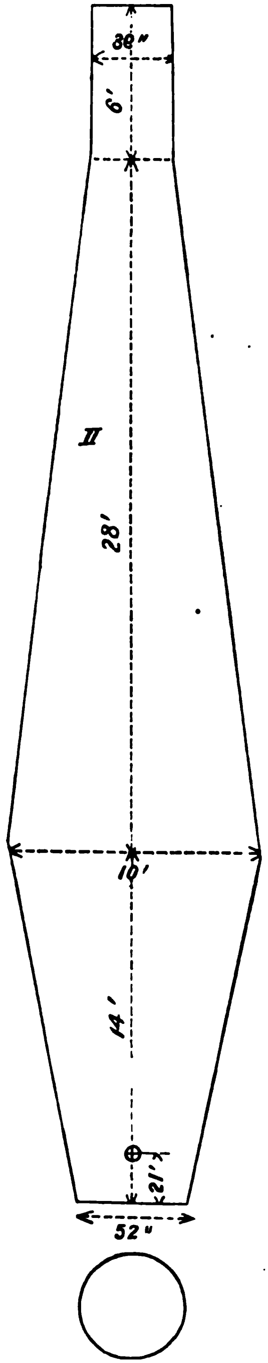

FIG. 15.

1. 91 per cent. of brown ore and 9 per cent. spathic ore. 2. Eight cylinders. 3. Five tuyeres. 4. 447 Vienna centners. 5. 7.85 cubic feet. 6. 47 per cent.

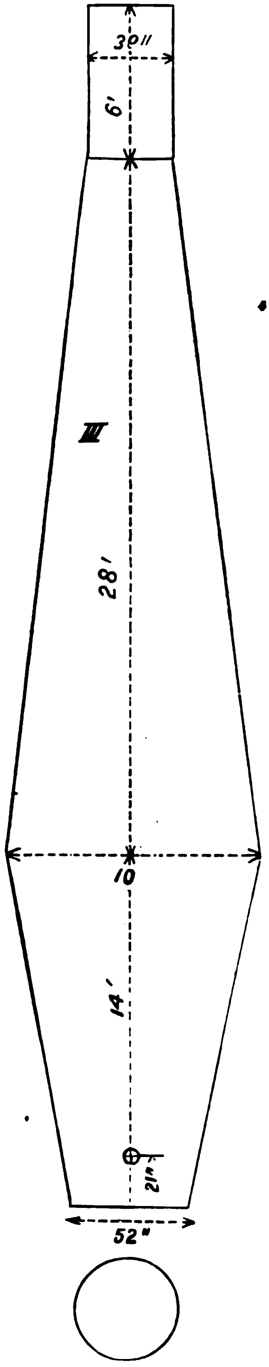

FIG. 16.

1. 91 per cent. of brown ore and 9 per cent. spathic ore. 2. Eight cylinders. 3. Five. 4. 422 Vienna centners. 5. 8.39 cubic feet. 6. 46 per cent.

URTL.

Last campaign, 1834.

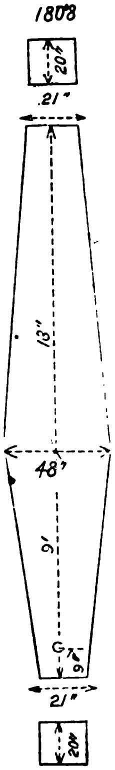

FIG. 17.

1. Brown ore and spathic ore.
2. Two box-bellows.
3. One.
4. 71 Vienna centners.
5. 21.7 cubic feet.
6. 38 per cent.

KOMPAGNIE HÜTTE.

Last campaign, 1812.

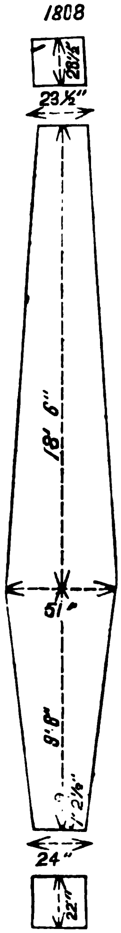

FIG. 18.

1. Brown ore and spathic ore.
2. "Schnbalge."
3. One.
4. 61 Vienna centners.
5. 21.1 cubic feet.
6. 48 per cent.

HEFT.

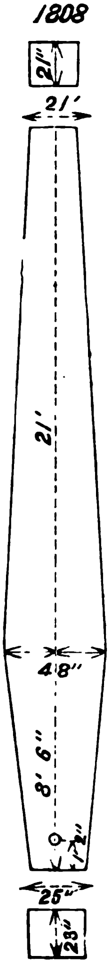

Fig. 19.

1. Brown ore and spathic ore.
2. Two box-bellows.
3. One.
4. 99 Vienna centners.
5. 12.7 cubic feet.
6. 50 per cent.

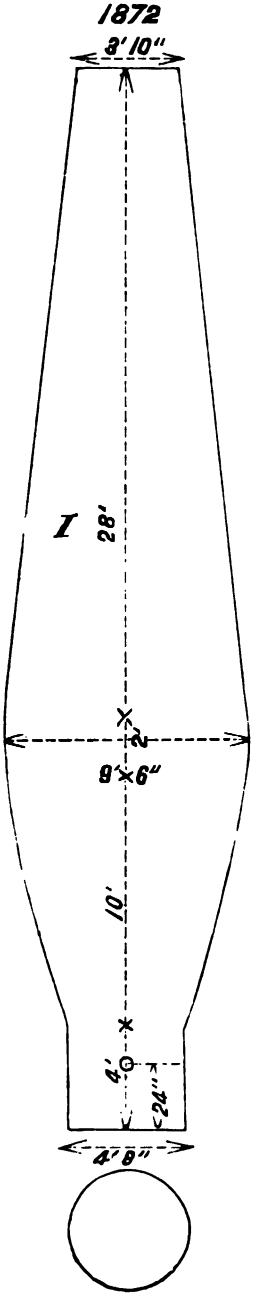

Fig. 20.

1. Brown ore and spathic ore.
2. Four oscillating, four fixed, and two horizontal cylinders.
3. Five.
4. 225 Vienna centners.
5. 9.87 cubic feet.
6. 50 per cent.

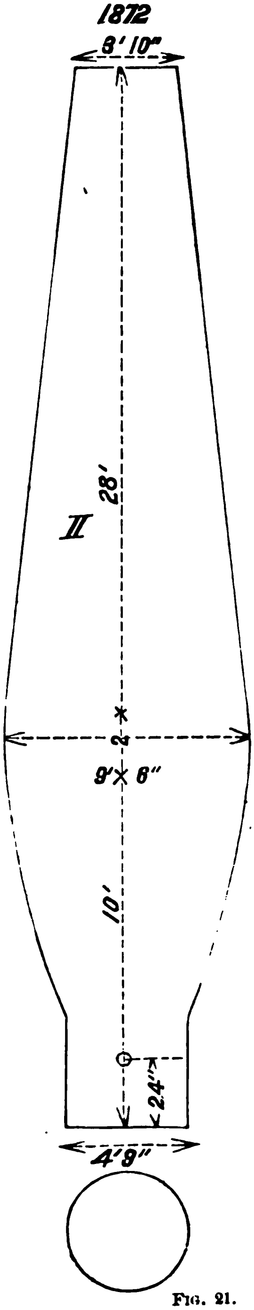

Fig. 21.

1. Brown ore and spathic ore.
2. Four oscillating, four fixed, and two horizontal cylinders.
3. Five.
4. 264 Vienna centners.
5. 9.58 cubic feet.
6. 51 per cent.

MOSINZ.

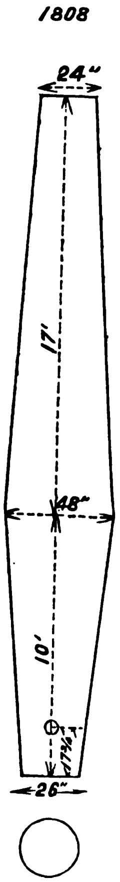

Fig. 22.

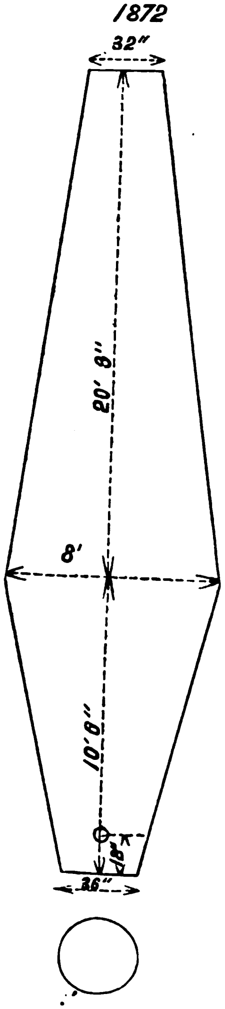

Fig. 23.

1. Brown ore and spathic iron-ore.
2. Two box-bellows.
3. One.
4. 90 Vienna centners.
5. 14.1 cubic feet.
6. 52 per cent.

EBERSTEIN.

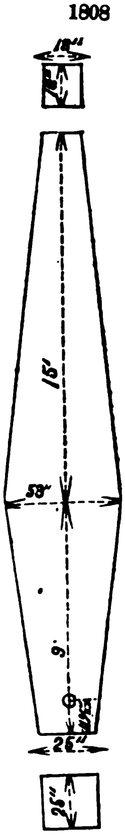

FIG. 24.

Brown iron-ore ¼, and spathic ore ¾.
Two "spitzbalge."
One.
53 Vienna centners.
16.8 cubic feet.
30 per cent.

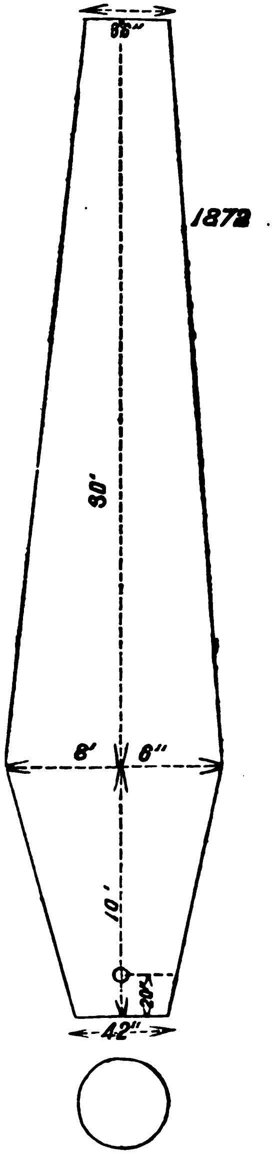

FIG. 25.

1. Brown ore ½, and spathic ore ½.
2. Two oscillating and two fixed cylinders.
3. Three.
4. 286 Vienna centners.
5. 9.88 cubic feet.
6. 47 per cent.

LÖLLING.

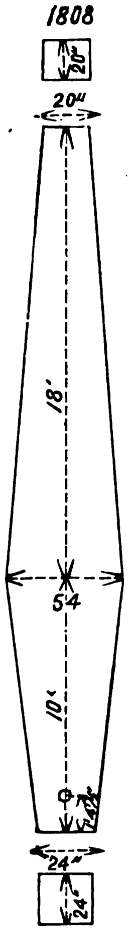

FIG. 26.

1. Brown ore and spathic ore.
2. Two box-bellows.
3. One.
4. 88 Vienna centners.
5. 11.8 cubic feet.
6. 50 per cent.

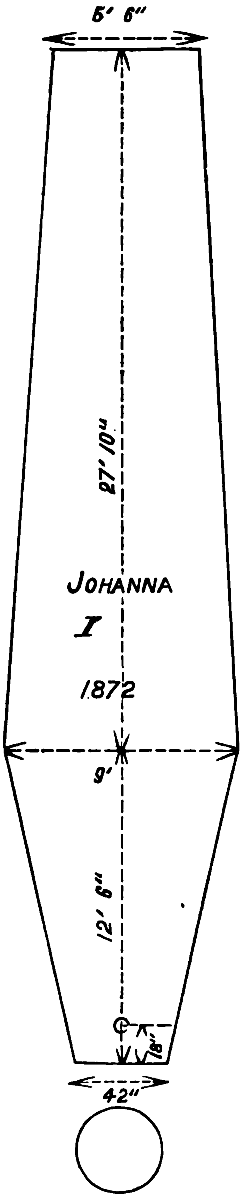

FIG. 27.

1. Brown ore 85 per cent., and 15 per c
   spathic ore.
2. Two fixed, two oscillating, and two h
   izontal cylinders.
3. Three.
4. 293 Vienna centners.
5. 9.13 cubic feet.
6. 50 per cent.

LÖLLING.

1872.

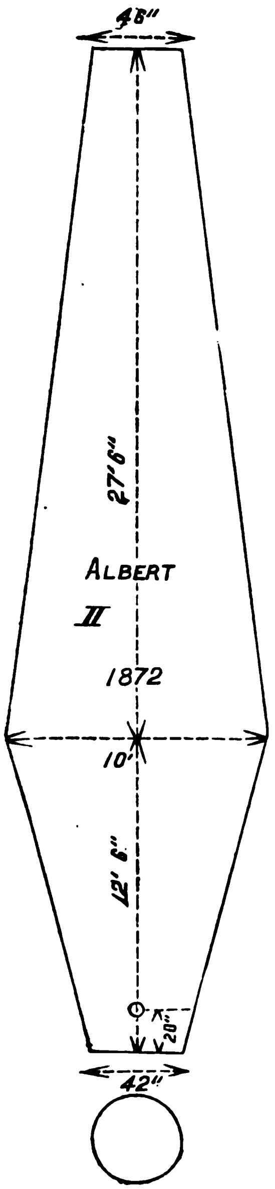

FIG. 28.

1. Brown iron-ore 85 per cent., spathic iron-ore 15 per cent.
2. Two fixed, four oscillating, and two horizontal cylinders.
3. Three tuyeres.
4. 296 Vienna centners.
5. 8.35 cubic feet.
6. 50 per cent.

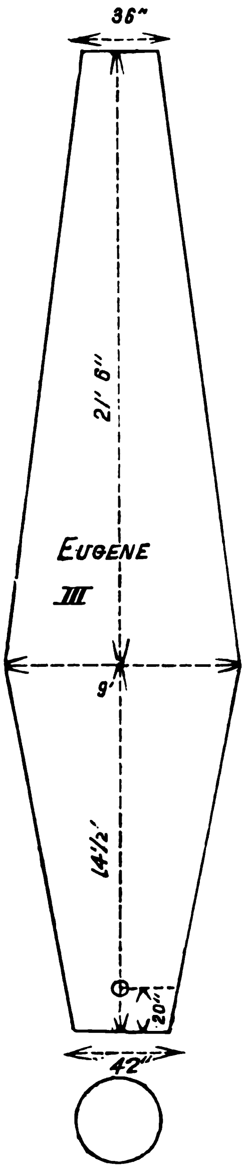

FIG. 29.

1. Brown iron-ore 85 per cent., spathic iron-ore 15 per cent.
2. Two fixed, four oscillating, and two horizontal cylinders.
3. Three tuyeres.
4. 325 Vienna centners.
5. 9.39 cubic feet.
6. 50 per cent.

MINDISCH-KAPPEL.

Last campaign, 1823.

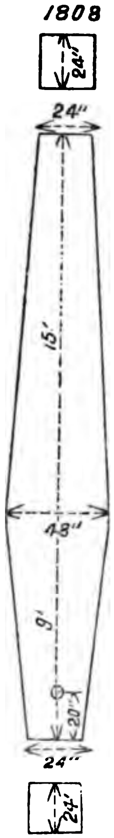

FIG. 30.

1. Red iron-ore, (hematite.)
2. Two box-bellows.
3. One tuyere.
4. 35 Vienna centners.
5. 25 cubic feet.
6. 38 per cent.

WAIDISCH.

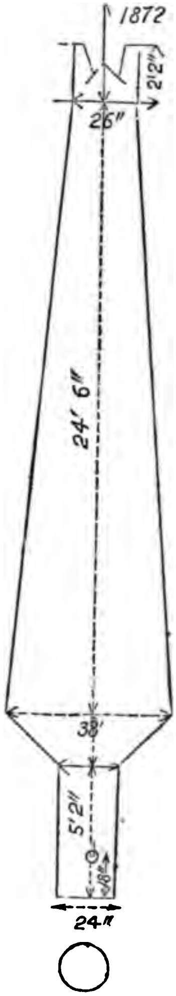

FIG. 31.

1. *Trischschlacke.*
2. One oscillating, one fixed cylinder.
3. One tuyere.
4. 50 Vienna centners.
5. 12 cubic feet.
6. 58 per cent.

WALDENSTEIN.

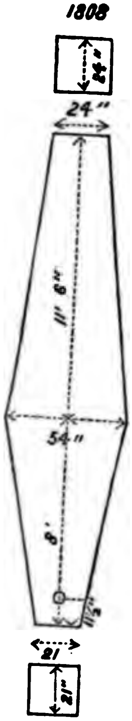

Fig. 32.

Brown ore ⅞, spathic ore ⅛.
Two box-bellows.
One tuyere.
38 Vienna centners.
26.2 cubic feet.
30 per cent.

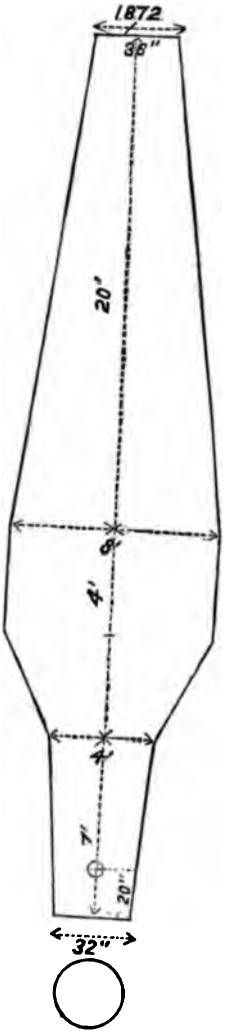

Fig. 33.

1. Specular ore, brown ore, and spathic ore.
2. Three "*wackler.*"
3. Three.
4. 115 Vienna centners.
5. 11 cubic feet.
6. 45 per cent.

ST. GERTRAND.

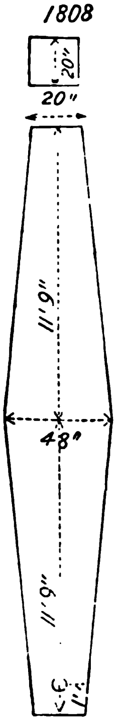

FIG. 34.

1. Brown iron-ore ¾, and spathic iron-ore ¼.
2. Two box-bellows.
3. One tuyere.
4. 57 Vienna centners.
5. 174 cubic feet.
6. 39 per cent.

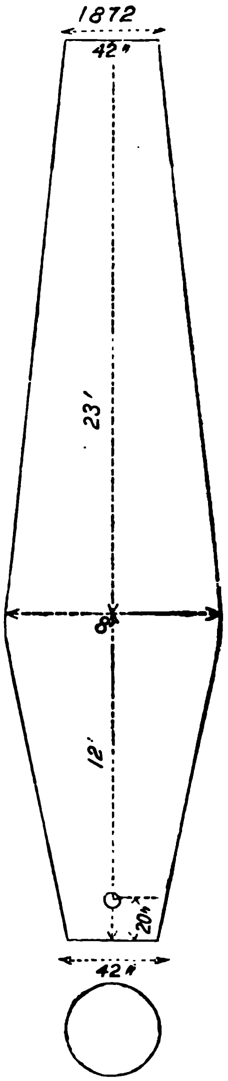

FIG. 35.

1. Brown iron-ore and spathic iron-ore.
2. Three cylinders.
3. Three tuyeres.
4. 120 Vienna centners.
5. 12.5 cubic feet.
6. 41.6 per cent.

ST. LEONARD.

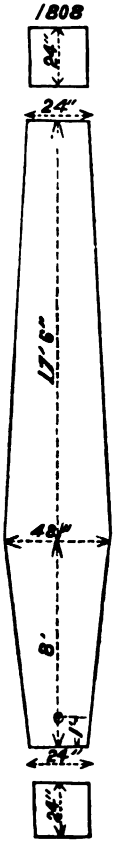

Fig. 36.

. Brown iron-ore ⅔, and spathic iron-ore ⅓.
. Two box-bellows.
. One tuyere.
. 53 Vienna centners.
. 18 cubic feet.
. 45 per cent.

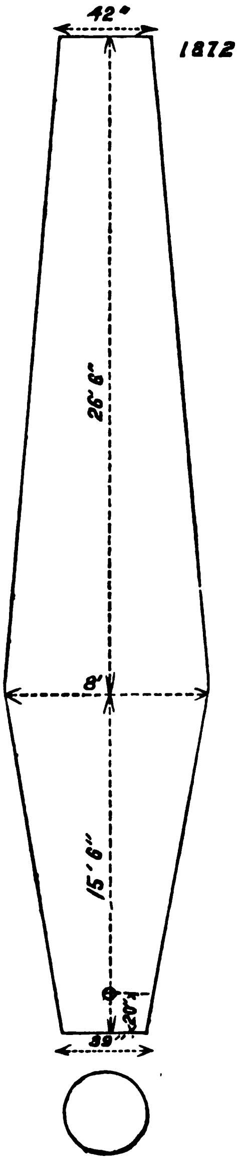

Fig. 37.

1. Brown iron-ore ⅔, and spathic iron-ore ⅓.
2. Two cylinders.
3. Three tuyeres.
4. 132 Vienna centners.
5. 10.4 cubic feet.
6. 42 per cent.

PREVALI.

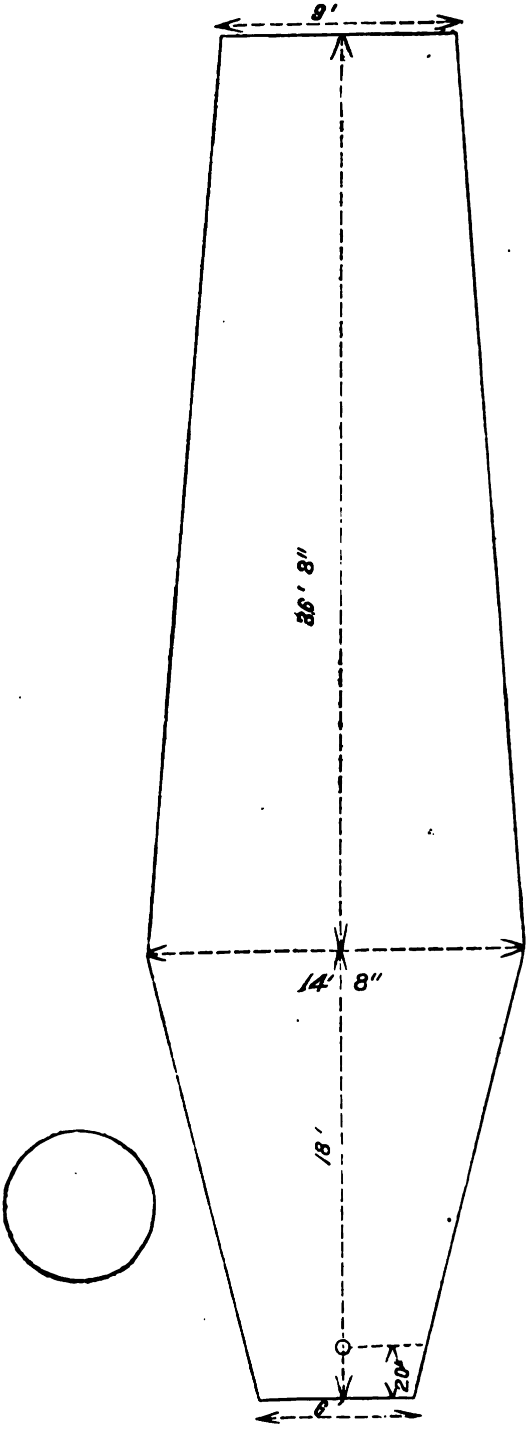

FIG. 38.

1. Spathic iron-ore.
2. Two cylinders.
3. Six tuyeres.
4. 601 Vienna centner
5. 150 pounds coke.
6. 84 per cent.

ENSIONS OF BLAST-FURNACES.—From data obtained at the , a writer in *Engineering* gives a very interesting tabular ex- .e sizes and yield of some of the principal blast-furnaces in

'rincipal dimensions of blast-furnaces in various parts of Europe.[*]

f furnace.	Number of tuyeres.	Height of furnace.	Diameter between.			Capacity of furnace.	Yield per week.	Remarks.
			Tuyeres.	Boshes.	Top.			
ection.		*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Cubic meters.*	*Tons.*	
coke-fur-	3	15.58	.94	4.7	1.88	117.58	56.25	Open breast.
coke-fur-	8	13.7	2.56	5.34	4	220.7	250	Closed hearth and top.
855, coke-	3	14.4	1.07	4.7	2.2	138.1	....	
865, coke-	• 7	14.8	2.5	4.7	3.14	204	....	Open hearth.
372, coke-	8	13.5	2.67	5.65	3.77	231.6	....	Closed hearth.
ırnace	3	16.8	1.4	5	3	158.7	175	
itte, 1861,	3	15	1.1	4.1	2.51	....	....	
ırnace	3	14.1	1	3.96	2	....	112	
loravia,	7	18.72	2.24	5.44	3.2 4.8	....	....	
hia, 1872 ..	6	16.96	1.93	4.68	2.88	....	240	
ɔal, 1799 ..	......	11.18	.90	3.45	.96	40.31	13.7	Open hearth.
oal, 1829 ..	2	13.14	.63	3.14	1.36	48.14	25	Do.
charcoal,	2	12.11	.76	3.22	1.25	46.9	....	Do.
;ary, char-	4	13.3	1	2.85	2.02	56.5	100	
Carinthia,	3	11.2	1.16	2.56	1.11	....	46	Charcoal-furnace.
Carinthia,	3	9.98	.85	2.56	.95	....	39	Do.
charcoal,	2	8.79	.63	2.05	.62	....	17.5	Open hearth.
al, Styria	......	13.27	1.89	2.26	.79	....	161	
Sweden ..	2	13.06	1.36	2.82	1.78	....	67.5	Charcoal-furnace.
eden	2	12.76	1.17	2.67	1.45	....	31	Do.
....	2	11.87	.94	2.37	1.39	....	24	Do.
gary......	......	9.28	.72	2.56	.85	....	....	Charcoal.

[*] Engineering, August 8, 1873, from the Vienna Exhibition.

MS ASSUMED BY FURNACES AFTER LONG WORKING.—In con- ;h this table of the principal dimensions of blast-furnaces, it :ructive to compare the dimensions which furnaces assume ng for a long time. Engineering justly observes:

ıble gives good evidence that no general rules have, up to the ıe, been deduced for the best form of blast-furnaces under ditions, as not even those furnaces which are in close vicinity her, and which are worked under similar conditions, have with corresponding dimensions.

ct will be understood easily enough when we say that only l designs for the construction of a blast-furnace to be erected ı place happen to be brought to the knowledge of metallurgi- rs; but never, or very seldom only, are the results and expe- ed in working this furnace brought before the public. This neral rules becomes the more striking when we find that nature itself has made the best engineer and draughtsman in this case, and that we only want to keep our eyes open to its teachings. Ambition and selfishness alone can have kept us so long from acknowledging these facts.

"It is clear that the best form of blast-furnaces will be that which, all other circumstances being equal, will work with the greatest economy of fuel and with the least deterioration of the furnace-lining. Now, instead of engaging ourselves with extended speculation about the mode of finding out the best form of furnaces, it would prove to be much wiser to look at the inside of such furnaces after they have worked effectively for some time. It is by no means a rare fact that blast-furnaces give the best working results a very short time before they are obliged to be put out of use on account of the general wear and tear of the lining.

"In all such cases the furnace itself, at the end of a campaign, will give valuable hints as to the form best adapted for the particular circumstances. But instead of learning, by close inspection, the wants of nature, in most cases we rebuild the furnace according to the original type, quite irrespective of the conclusions which may be drawn from the excessive deterioration of some parts of the interior.

"It is more than probable that the comparison of a series of such *self-formed* sections of blast-furnaces at the end of their campaigns will afford us means of deducing certain formulæ for the determination of the most effective form of coke or charcoal blast-furnaces, with due reference to the different circumstances under which they may work. But to arrive at such a desirable result, it is necessary before all that the different iron-masters and metallurgical engineers should aid the undertaking, by publishing the results obtained with furnaces of certain construction, and at the end of each campaign give a complete section showing the wear and tear of the lining. We believe it to be of the highest interest to all connected with the iron-trade that such knowledge should be largely diffused among the iron-works proprietors and metallurgical engineers."

Accordingly, *Engineering* presents sections obtained from drawing at Vienna of a charcoal blast-furnace, exhibiting in a striking manne the modification of the form of the interior after a campaign of fiv years' duration. These drawings are here reproduced. They represen one of a set of three furnaces at Mariazell, in Styria, working calcine spathic ores containing 42 per cent. of iron. It was lined with bric and the crucible was built of sandstone. The broken lines in the vert cal and horizontal sections show the ultimate shape assumed.

The furnace was working well when stopped on account only of t falling of part of the brick lining.

There is a striking similarity between these sections, the result c wear, and the form considered in some parts of Styria as the best fc smelting spathic ores. Take, for example, a section of a charcoal blas

Vertical sections of Mariazell furnace.

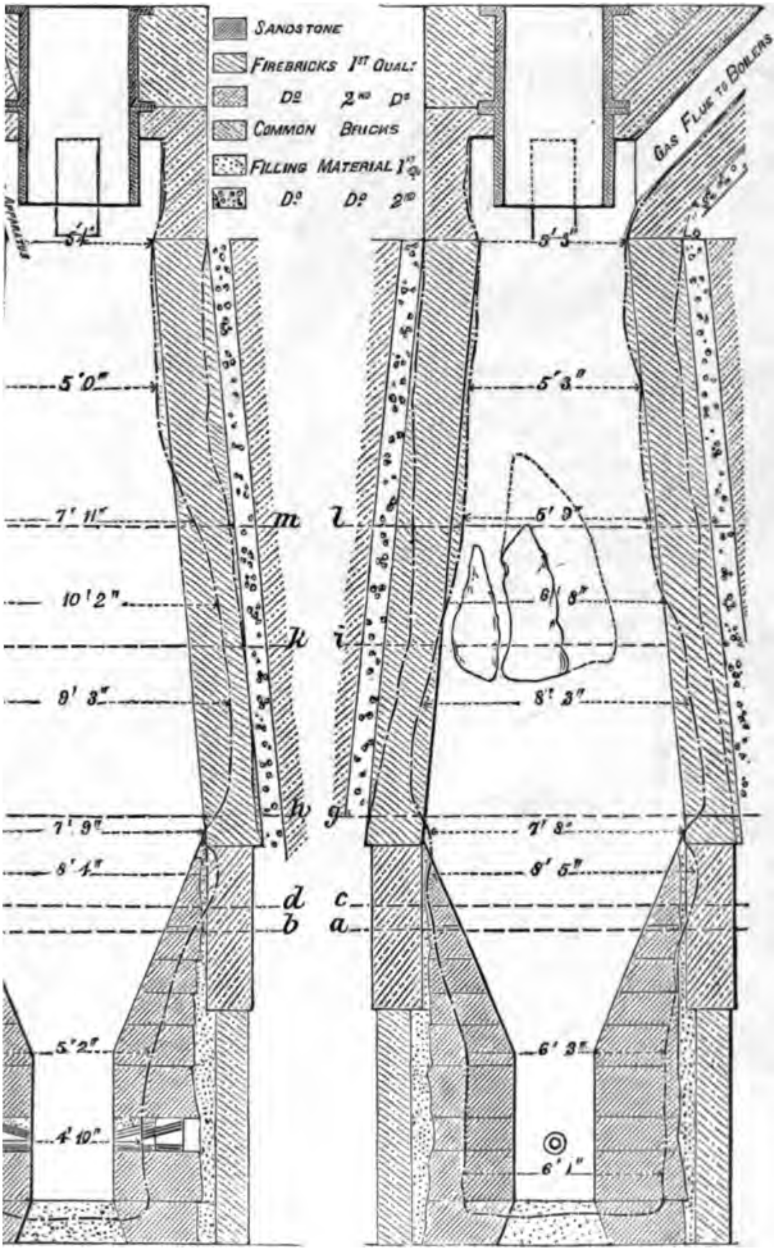

FIG. 39. FIG. 40.

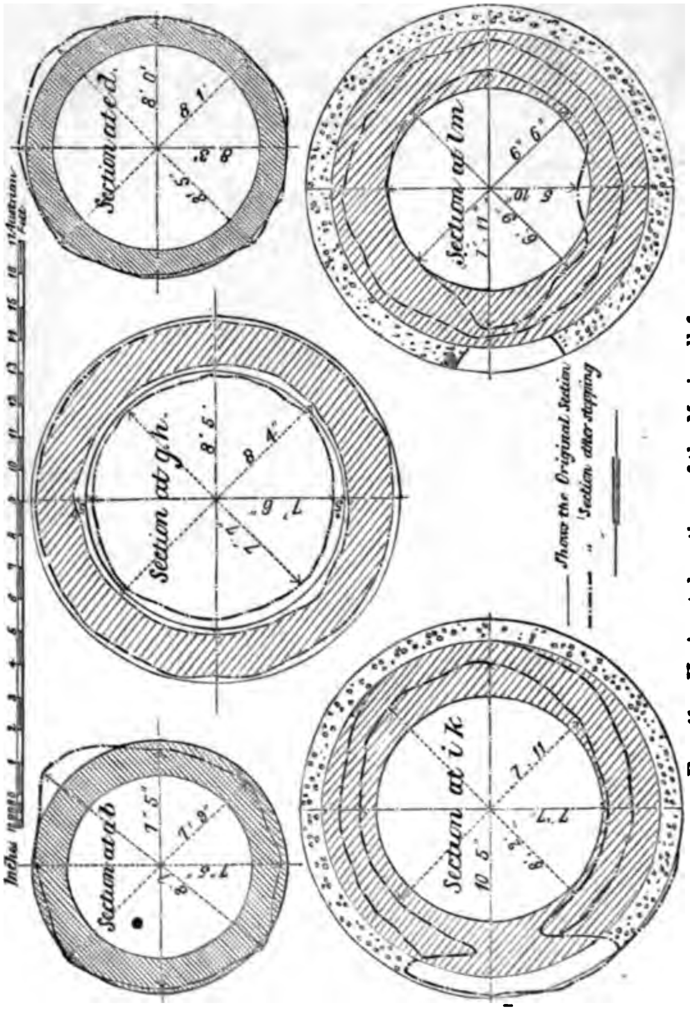

FIG. 41.—Horizontal sections of the Mariazell furnace.

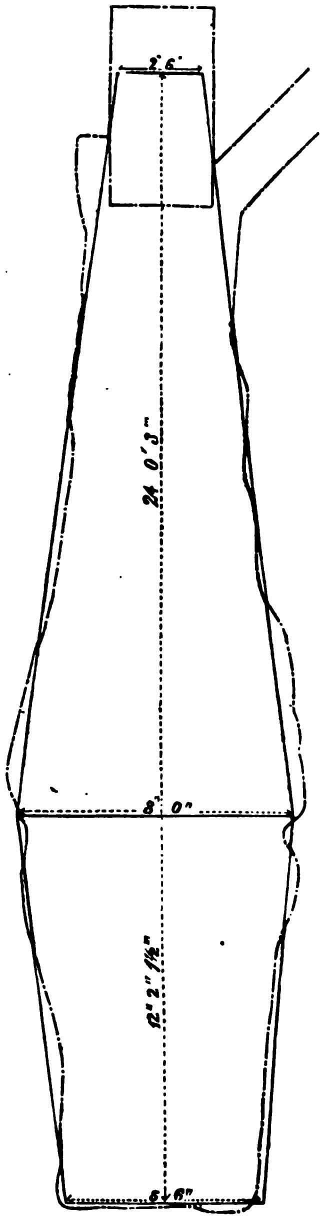

FIG. 42.—Vertical section of Styrian furnace.

furnace at Hieftau, near Eisenerz. It is nearly the same as the ultimate section of the Mariazell furnace.

In further illustration and confirmation of this tendency to assume a form corresponding closely to the shape and proportions believed to be the best in Styria, sections of another of the three Mariazell charcoal-furnaces are shown. These are contributed by J. Stummer-Traunfels, of Vienna, to *Engineering*, in corroboration of the views expressed, and are also very instructive. This furnace was also working in a satisfactory manner up to the time of the stoppage of the blast for the purpose of putting in a new lining. It had been in blast continuously for three years, and produced good iron with economy of fuel.

RESCHITZA STATE RAILWAY.

26. This company makes one of the most complete of the exhibitions of iron and steel, including the fuel used and models of the mines and apparatus for extraction of the ore. We here find a complete section of a bed of coal, showing the roof and floor, with a clay parting in the midst of the bed. This specimen is 14 feet 4 inches long, and stands about 6 feet high, the seam being inclined to the horizon. Here, also, is the largest Bessemer-steel ingot in the exhibition, 7 feet 1 inch long, and 33 inches in diameter, weighing 8,925 kilograms. There are, besides, a series of steel ingots, test-objects, showing the character of the fracture; a series of sections of rails with hard crystalline heads, and fibrous bottom, some with steel head and iron base. A series of sections of shape-iron of various forms is shown to illustrate their internal structure, one being polished, and the other etched in acid, bringing out in this way the folding of the layers in the bars or the "fibrous" structure. A large tire for railway driving-wheels, 8 feet 9½ inches in diameter, attracts attention on account not only of its size, but its lightness and perfection of form.

In a fish-plate joint for rails a method of preventing the nuts from turning is shown. A small square plate of steel or iron, about one-eighth of an inch thick, is placed under the nut, and one side is raised up by a stroke of a chisel applied under the edge.

27. FERRO-MANGANESE.—A notice of the splendid exhibition in the Reschitza pavilion would be incomplete without more than a passing reference to the samples of ferro manganese, or mangan iron, of three grades, containing from 25 per cent. to 35 per cent. of manganese. This alloy is very important in the manufacture of steel, and with the growth of the industry of steel in all parts of the world it assumes a constantly-increasing importance. The home-production of ferro-manganese is greatly needed in the United States, where it certainly might be made with our manganiferous ores and abundant fuel at a moderate cost. The process of manufacture, it will presently be shown, is very simple, attention however, being requisite to some important points, which might be overlooked and prevent success. At present the foreign metal is thrown into

Vertical sections of blast-furnace

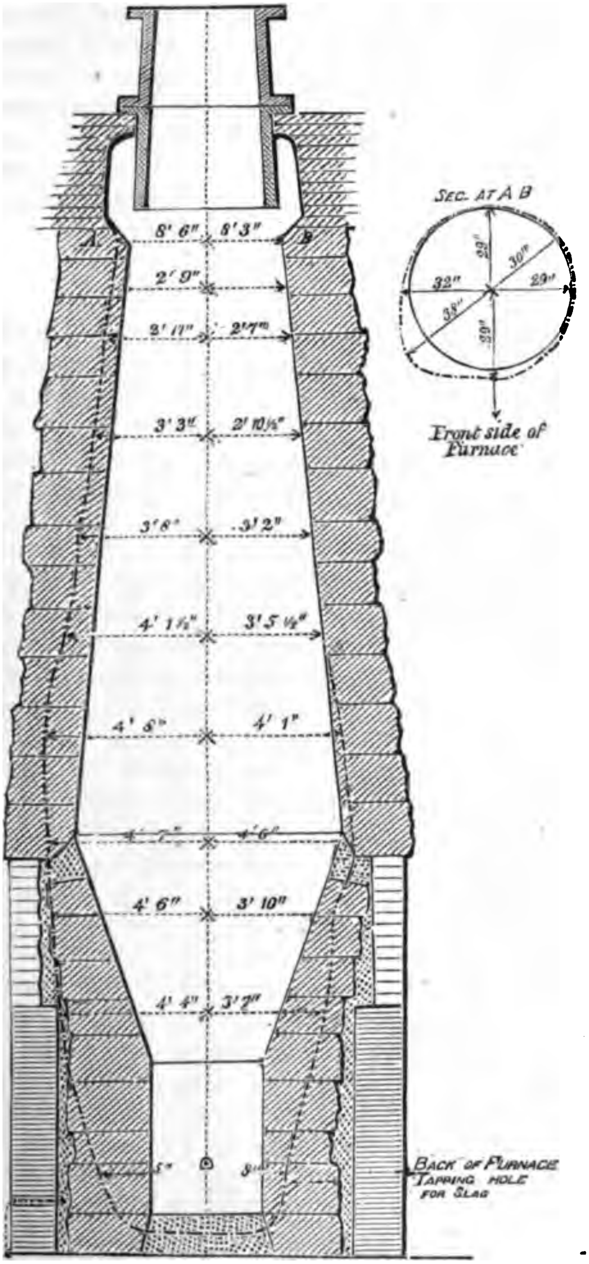

FIG. 43.

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[illegible]

arket at constantly-decreasing prices. This, and in general the ratively small quantity required by our steel-establishments sep- ', appear to have discouraged the investment of capital in a special aking for the manufacture of ferro-manganese upon a large scale supply of the home demand.

At Reschitza, and probably at Laibach also, (the *Krainische Indus- sellschaft,*) ferro-manganese is made in a blast-furnace, with char- fuel and limestone as the flux. The ore is a ferruginous mixture, ning about 37 per cent. of sesquioxide of manganese. It is sili- and somewhat resembles in appearance the hard manganese-ore ed Island, in the Bay of San Francisco, California. It contains 29 per cent. of silica and some alumina, as shown by the sub- analysis:

Analysis of ore used at Reschitza for ferro-manganese.

	$Si\,O_3$	28.613
ıa	$Al_2\,O_3$	8.073
Protoxide	Fe O	0.367
Sesquioxide	$F_2\,O_3$	19.031
)xide of manganese	$Mn_2\,O_3$	37.224
	Ca O	2.430
sia	Mg O	0.261
	H O	3.361

ore in the furnace requires a large amount of limestone to be ıs flux. The larger the quantity of limestone used, or the more basic the charge is made, the larger is the percentage of man- in the product. Thus, by using 15 per cent. of limestone and 85 ıt. of ore, the product contains about 25 per cent of manganese. ng the amount of limestone, about 5 per cent. additional of man- is gained, giving, say, 30 per cent. of manganese; trebling the y of limestone, the metal containing 35 per cent. of manganese. o recapitulate results which have been obtained, we have:

ıestone ....
.nganese-ore .... } =25 per cent. manganese.

limestone ....
manganese-ore .... } = 29 per cent. manganese.

ıestone ....
nganese-ore .... } = 35 per cent. manganese.

trial with the ore of which the analysis is given, 43 per cent. of ne was added, so that the oxygen ratio of the bases to that of the acid was as 15.88 to 10.68 = 1.48 to 1, or nearly as 1½ to 1. This for charcoal is a highly basic charge, but it is a most important condition in the manufacture of mangan iron.

To prevent the slagging-up of the furnace, it is necessary to have a high pressure of blast, much greater than is generally used in charcoal-furnaces, and as high as 90 to 100 millimeters of quicksilver. The blast, moreover, must be highly heated. In this instance it was carried to 250° Celsius = 482° Fahrenheit, the highest point attainable with the heating-apparatus of the Reschitza works at that time. With a higher temperature of blast and still more limestone, an alloy containing at least 50 per cent. of manganese could be produced. The furnace must be kept very hot, and the limestone always in excess.

The quantity of materials used and the costs of production can only be stated approximately. At Reschitza it was approximately as follows:

	Fl.	kr.
1,400 kilograms of ore	2	94
5 hectoliters charcoal	2	00
600 kilograms limestone		21
Labor, &c	1	00
Total in Austrian florins	6	15

The product being 50 kilograms of ferro-manganese, containing 35 per cent. of manganese. This sum is equivalent to, say, $3.10 for 100 pounds of ferro-manganese, being at this rate over $60 per ton.

MIXTURES OF IRON AND BESSEMER STEEL.—There were some very interesting specimens illustrative of the effects produced upon soft gray pig-iron by adding Bessemer steel in increasing quantities. The specimens present a regular gradation in fracture from soft gray pig to hard white metal. Some large rolls for rolling iron were shown to which 12 per cent. of Bessemer steel had been added.

29. The *Krainische Industrie-Gesellschaft* of Laibach, Tyrol, exhibit an interesting series of specimens of spiegel iron and ferro-manganese, ranging from 8 to 35 per cent. of manganese. The alloy containing the high percentage of manganese is in blocks 9 inches thick, and breaks with a finely-bladed or columnar fracture, not exhibiting brilliant crystalline plates, but rather a fibrous structure. The ores are also shown, together with manganese and bauxite.

30. ROSITZER MINING COMPANY.—The *Rositzer Bergbau-Gesellschaft* make a very attractive installation illustrating their works and products. The whole does not occupy more than ten feet square at the base, but is in the form of a pyramid, rising about ten feet high, and formed of sections of rolled girders of different sizes, the largest at the base, and upon them samples of the pig-iron and of steel proof-ingots broken asunder, of bars and shafts broken across, and sections of rails and angle-iron. The ores (slags, fluxes, &c.) are also shown in an attractive

Ve also find castings, hoop and rod iron, model of workmen's model of the machinery at the shaft; the hoisting-gear; a large : two wagons side by side, fitted with a hood, eccentric safety-, and a spiral spring.

re-brick used are also shown. Some of them are of great size, r more in length and 9 inches thick, remarkable for their sharp- excellence. Specimens of coal-fossils, photographs, and blocks n the top of the pyramid, complete this compact and well-made

JDENBURGER IRON-WORKS.—The joint-stock company "Juden- Eisenwerke," of Vienna, exhibited a number of boiler-plates of e, a plan of the works at Judenburg, and a graphic chart of on and prices for the last eight years. The dimensions of some lates were—

iotive frame-plate, 8,015 × 765 × 9 millimeters, weighing 426 ns. Annual production, 1,600 to 2,000 pieces.

r frame-plate, 5,070 × 770 × 9 millimeters, weighing 264 kilo- Annual production, 1,600 to 2,000 pieces.

-plate, 2,180 × 1,505 × 15 millimeters, weighing 393 kilograms. production, 3,000 to 3,500 pieces.

2,000 × 290 × 28 millimeters, weighing 126 kilograms.

2,709 × 1,500 × 2 millimeters, weighing 71.5 kilograms. production, 7,000 to 8,000 pieces.

12,008 × 1,290 × 9.35 millimeters, weighing 1,071.23 kilo-

4,346 × 1,948 × 8.80 millimeters, weighing 546.10 kilograms.

3,265 × 1,580 × 0.616 millimeters, weighing 24.5 kilograms.

2,249 × 1,602 × 0.244 millimeters, weighing 6.47 kilograms.

2,344 × 1,356 × 0.183 millimeters, weighing 4.5 kilograms.

rincipal market for these plates is in Vienna, for the manufac- locomotive-boilers, for steamboat-boilers, on the Danube, and at Brünn, and Pesth. Plate was supplied last year for over motive-boilers. The following is a tabular statement of the ion and price per zoll-centner for the last eight years:

Year.	Boiler-plate in zoll-centners.	Average price.	Total value.
		Fl. *kr.*	*Fl.* *kr.*
	22, 232. 03	8 79. 4	195, 525 78
	25, 075. 69	7 94. 7	199, 290 31
	48, 275. 24	7 10. 3	342, 923 80
	70, 922. 63	7 25. 6	515, 161 00
	90, 603. 42	8 31. 2	753, 098 53
	90, 451. 94	8 97. 3	811. 646 29
	103, 057. 11	9 04. 5	932, 144 73
	116, 465. 91	9 21. 6	1, 073, 311 20
	125, 321. 81	10 34. 8	1, 296, 777 16

property of the Judenburger Company consists of puddling ling mills at Judenburg; coal-mines at Zeltweg, Styria; iron-mine and blast-furnace at Olsa, Carinthia; rolling-mills in Hetzendorf, Styria.

At the rolling-mills of Judenburg there are 3 turbine wheels of 20 horse-power, one of 90 horse-power, and a water-wheel of 100 effective horse-power for a line of plate-rolls; three trip-hammers, one of which has a falling-weight of 24 and the other two of 20 centners; a large steam-engine of 200 horse-power for a line of plate-rolls.

There are, in addition, one large steam-hammer, with a falling-weight equal to 300 centners through one inch, and a five-foot stroke; 2 large steam-shears, with seven feet cutting-length, to cut 18 lines thick, cold; 10 puddling-furnaces; 2 Siemens heating-ovens; 10 heating-ovens of other construction; and a variety of other accessories to the manufacture.

This is the largest establishment for the manufacture of boiler-plate in Austria. The first Siemens welding-furnace was set up in 1869. The product of one furnace in twelve hours is usually over 3,000 kilograms, and sometimes rises to 5,000 kilograms. Over 300 workmen are employed. The pig-iron is obtained partly from the company's furnace at Olsa and partly from the blast-furnace at Treibach, from Vordernberg, and from Eisenerz. The coal comes chiefly from the company's mines at Zeltweg.

The works at Hetzendorf are intended chiefly for the manufacture of long sheets of plate-iron and plate of superior quality. The power is derived from a turbine wheel of 120 horse-power for a set of universal rolls; one turbine, of 60 horse-power, for a set of bloom-rolls; one turbine, of 20 horse-power, for the accessory work. There is one steam-hammer with a falling-weight of 100 centners, 6 feet stroke; one of 60 centners, 5 feet stroke; two Siemens welding-furnaces; seven puddling-furnaces; four heating-ovens for plate; and the corresponding shears and accessory machinery.

32. ROTARY PUDDLER.—A model of a rotary puddling-furnace plant, with regenerative furnaces, according to Dr. Siemens's plan, is shown by Joh. Willroider, of Villach, in the Carinthia building. The gearing is applied below; it is sustained upon plane-faced wheels. The opening at the back is closed by a square sliding door, and the puddled ball is to be withdrawn through this opening and to drop through a chute below into a car in the pit under the rotating vessel. The flame enters and returns on opposite sides of a vertical wall, while in the Sellers puddler in the United States section the division is horizontal.

33. EHRENWERTH'S PUDDLER.—We have in the same building a model of a new form of rotary puddler, designed by Joseph v. Ehrenwerth, of the K. K. Bergakademie zu Pribram, Bohemia. The two vertical sections annexed will serve to show its construction and method of working.

The horizontal pan-shaped hearth A (Figs. 45 and 46) is supported upon a pivot, W, to which motion is imparted by bevel-gearing. An

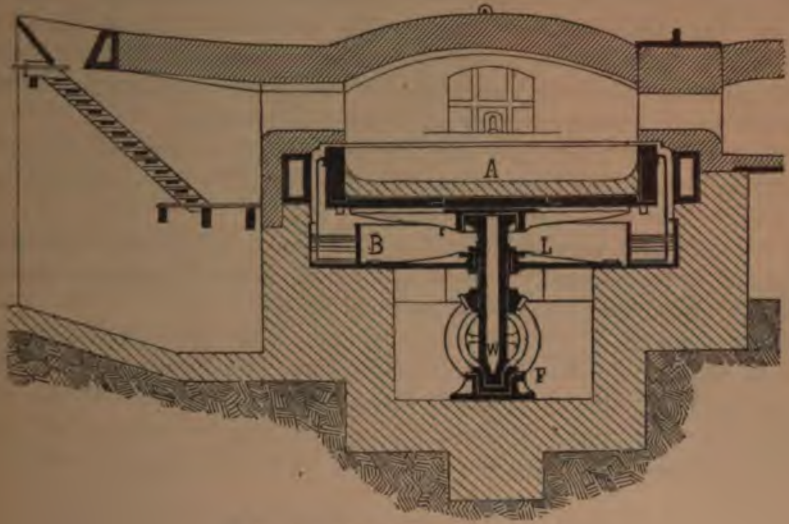


FIG. 45.—Longitudinal section.

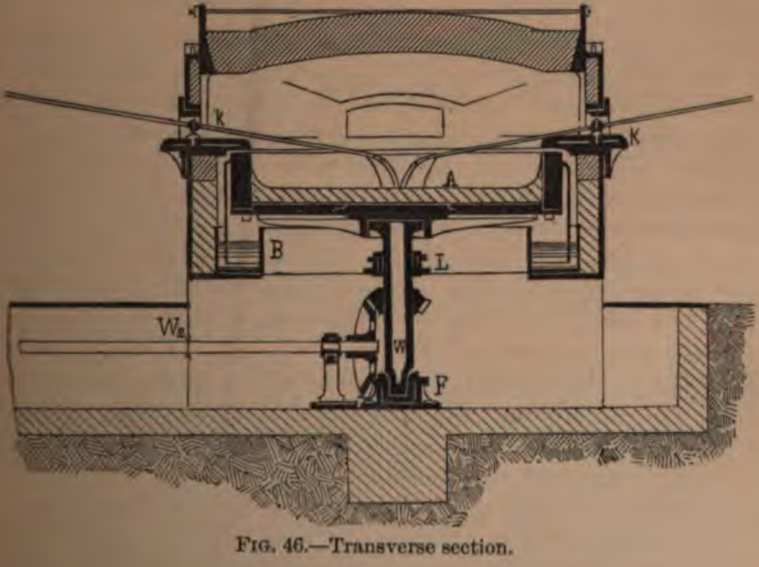


FIG. 46.—Transverse section.

EHRENWERTH'S ROTARY PUDDLING-FURNACE.

annular trough filled with water below the rim of the hearth serves to form an air-tight joint, keeping the flame from the gearing and supports below. The rabble is fixed at one side. The cost is stated at about $2,000. Its value for the intended object remains to be shown by use.

The annexed additional description is translated from the inventor's circular stating the advantages of this form of puddler.

The puddling-furnace with rotating hearth differs from the ordinary puddling-furnace only in the fact that the hearth, which is fastened to a vertical shaft, can be set in rotation.

Any method of heating desired can be used. The model represents a furnace with gas-heating apparatus with Siemens regenerators, and the drawing such a furnace with inclined grate.

In the drawing, F is the foot-journal and L the neck-journal, W the vertical shaft, A the hearth, which is fastened to the rosette *r*.

The hearth consists of the bed-plate and the hearth-wall. Both are formed of many pieces of cast iron, as indicated in the model. The hearth-wall can be coated on the inside with any suitable refractory material.

In order to exclude the air from the interior of the furnace, a cylinder of plate is fastened to the bottom of the hearth, or to the wall of the same, which dips in water contained in the annular basin B, having constant inflow and exit. The annular basin is attached, air-tight, to the furnace-wall.

In order to cool the bottom, jets, with roses attached, are introduced, which sprinkle water against it. The cooling of the side-walls is effected in different ways according as the cylinder of plate, necessary for the exclusion of the air, is attached to the bottom or to the rim of the hearth. In the first case the parts of the wall are hollow, as shown in the model, and the cooling-water is conducted through pipes *r* under pressure into the hollows. The escaping water falls over the lower edge into the basin, (model.) In the latter case, which is to be more recommended, the cooling-water is conducted against the hearth-wall through jets fixed in a circle, and then drops into the basin. In this case the hearth-walls may be made solid.

The motion of the hearth is imparted to it by means of toothed gearing, from the driving-shaft W_2, which is set in motion by means of a belt from a main shaft. For large works it is advantageous to have one subterranean main-shaft common to all the furnaces.

The operation of the hearth is as follows: After the charging is finished the hearth is set in rotation. If it is intended to stir the bath after complete melting, then rabbles provided with broad blades placed obliquely are introduced through the balls *k* inserted in the furnace-doors, and the puddling is performed either by hand or machine, from the edge of the hearth toward the center. If the rabbles are placed obliquely from opposite sides, and one worked toward the center and the other toward the outside, the best possible puddling is obtained by means of this double motion of the hearth and rabbles.

The blooming is done by hand as ordinarily in the furnace with fixed hearth, and during this time the hearth is intermittently in motion, in order, after completion of a bloom, to bring another mass of iron again before the door.

After the blooming the hearth is again set in rotation, in order to expose the blooms to as uniform a heat as possible. The blooms are afterward taken out and drawn in the usual way.

The excess of slag, formed by each new charge, is taken out at the end of the process by means of a ladle. (It can, however, be allowed to flow off, during the working, over two places in the hearth-wall, which are lower than the rest.)

The charge for a furnace with two working-doors is 15 to 20 centners. To work such a furnace, when the puddling is not done by machinery, four men are generally necessary, two or three workmen, and a fireman. The power required is about ½ to ¾ horse-power. The most advantageous number of revolutions during the puddling is about 20 to 24 per minute. The advantages which the puddling-furnace with rotating hearth offers are based upon the facts that the working is done either partially or wholly by machinery, and in consequence of the rotation of the hearth all parts of the iron pass through the same phases of heat, and are also entirely and uniformly heated. The advantages over the ordinary puddling-furnace are especially the following:

1. Cheaper production, in consequence of the saving of fuel and hand-labor.
2. Increased production with an equal outlay of capital.
3. Independence of the ordinary puddler. Even with the fixed rabble the work is accomplished.
4. Uniformity of product, in consequence of thorough puddling and uniform heating.
5. Easy regulation and control of the running.
6. Saving in health and comfort to puddlers.

This rotating-hearth puddler is claimed also to be especially well suited to steel-puddling, and to offer greater advantages to this than for iron-puddling.

34. HYDRAULIC FORGING.—A suit of parts of railway running-gear and of parts of locomotives is shown by Mr. Haswell, of the Imperial State Railway Works, near the depot of the Southern Railroad, Vienna. These objects are extremely interesting, not only to manufacturers of locomotives, car-wheels, &c., but to industry in general, as illustrations of what may be accomplished by Haswell's method of forging iron or steel by direct pressure, slowly applied to the metal while hot. The description of this method forms a separate chapter of this report.

35. WIRE-ROPE TRACES.—The St. Egydy and Kindberger Iron and Steel Industry Company, formerly Anton Fischer, of Vienna, exhibited a large number of wire-rope traces adapted to farming purposes, wagons, and wherever leather traces or chains are used for draught.

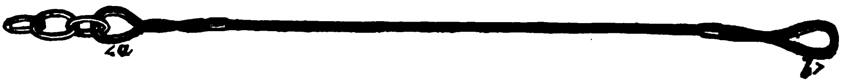
These traces have the advantages of great strength, lightness, pliability, and durability, and, besides, are cheap, as will be seen from the annexed table of sizes and prices. The lengths are stated in Austrian feet, and the price in florins and kreutzer.*

Sizes and prices of iron traces.

[Length in Austrian feet.]

Diameter in lines.	3½ to 4.	Over 4 to 4½.	Over 4½ to 5.	Over 5 to 5½.	Over 5½ to 6.	Over 6 to 6½.	Over 6½ to 7.	Over 7 to 7½.	Over 7½ to 8.
	Fl. kr.	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*	*Fl. kr.*
2½	1 90	1 95	2 00	2 05	2 10	2 15	2 20	2 25	2 25
3	2 05	2 10	2 15	2 20	2 25	2 30	2 35	2 40	2 55
3½	2 25	2 30	2 35	2 45	2 50	2 60	2 65	2 75	2 90

The form of these traces and the arrangement of loops and links at the end are shown in the figure.



Galvanized iron-wire traces.

The loops at the ends are fitted with metal guards to receive the wear. The rings are made of wrought iron. The lengths stated are from *a* to *b*. The rings add from four and a half to six inches. The whole surface is galvanized or zinked to prevent rusting.

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* The Austrian foot = 1.0371 feet; Austrian florin = 50 cents, approximately; and the kreutzer half a cent.

CHAPTER II.

GERMAN EMPIRE.

xtent and arrangement of the iron and steel display; Extent of the production; Chief localities; Rapid growth of the industry; Development of steel-manufacture; Cast steel; Graphic illustrations of production; Imports and exports; Number of exhibitors; Borsig's display of large boiler-plate; Dillinger sheet-iron; Styrum Company; Iron shoes for railway-brakes; Königs and Laurahütte; Iron girders and columns, Burbach Works and Phœnix Iron-Works; Iron railway-ties, Burbach, Schaltenbrand, and others; Krupp's display; Description of the works and products shown; The fifty-two-ton ingot of crucible steel; Artillery material of crucible steel; Buttgenbach's blast-furnace; Osnabrück Iron and Steel Works; Gleinitz furnace; Dimensions of furnaces at different periods.

36. The exhibition of the iron and steel industry of the German Empire is magnificent and highly instructive. It is arranged with the ther mining and metallurgical products chiefly in a special building, between the Industry Palace and the Machinery Hall, while Krupp's unrivaled display occupies another structure alongside.

37. The total values of the ores raised in the empire, exclusive of Elsace and Lothringen, in the year 1870, amounted to 7,116,828 thalers, as shown by the statistics presented at the exhibition, from which the annexed statement of the number of establishments, men employed, and the aggregate production in the year 1871, is compiled:

	Number of works.	Number of men.	Production.	Value.
			Cwt.	*Thaler.*
ron-ores	1, 258	24, 973	58, 550, 539	7, 116, 828
ast iron	631	39, 525	29, 942, 264	49, 251, 650
rought and rolled iron	354	43, 849	17, 437, 766	57, 490, 264
teel	216	12, 892	3, 399, 027	22, 747, 626

38. The chief seats of the German iron-industry are the Silesian rovinces, Westphalia, and the Rhenish provinces of the kingdom of russia. The great increase of the development of this industry of te is shown by the fact that the production of pig-iron, which in the ear 1825 did not exceed 1,004,162 centners, amounted to nearly 0,000,000 centners in the year 1871. According to the returns of the nited German customs, there were in 1861 469 cupola-furnaces, Prussia, 310;) 207 iron-wire works, (Prussia, 166, of which 146 were in he province of Westphalia;) 296 steel-works, including steel-rolling nd steel-wire works, (Prussia, 275;) 982 iron and tin ware works, including scythe, chain, anchor, nail, and other works, with 13,336 workmen, (Prussia, 794; Bavaria, 66; Würtemberg, 42;) 548 steel-ware and edge-tool works, with 3,081 workmen, (Prussia, 460, of which 427 were in the Rhine provinces;) 421 iron-railing works, heating and cooking apparatus works, with 12,077 workmen, (Prussia, 242; Sax-

ony, 43;) 50 manufactories of arms, with 4,188 workmen, (Prussia, 35;) 65 nail-works, with 3,729 workmen, (Prussia, 34; Bavaria, 30.)

39. In the year 1871, Prussia alone produced 5,689,944 centners of cast-iron ware in 492 works, with 24,600 workmen; 1,840,159 centners of sheet-iron in 59 works, with 4,536 workmen; 157,443 centners of tin-plate in 6 establishments, with 826 workmen; 1,091,042 centners of iron wire in 43 works, with 3,185 workmen; 3,664,064 centners of steel in 78 establishments, with 15,290 workmen, of which 2,963,313 were cast steel in 34 works, with 13,656 workmen.

40. The development of the Prussian steel-industry is extremely interesting. In the year 1825, the production did not exceed 62,065 centners. In 1832, a small quantity, 94 centners, of cast steel was made, but the quantity of steel increased rapidly to 723,297 centners in 1862, including 274,662 centners of cast steel. Upon the general introduction of the Bessemer process in 1863, 579,508 centners of cast steel were made, while the total steel-product rose to 952,767 centners. The percentage of cast steel in the total manufacture amounted in the year 1832 to less than 6 per cent., in 1850 14 per cent., in 1855 to about 29 per cent., 1862, about 38 per cent., in 1863, nearly 60 per cent., and in 1871 to about 71 per cent.

Prussian ores.

	1873.	1872.	Increase.	Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Bog iron-ore	25, 685	29, 012	....	3, 327
Brown hematite	1, 574, 657	1, 651, 550	....	86, 893
Spathic carbonate	742, 900	771, 465	....	28, 565
Clay ironstone	55, 396	26, 767	28, 629	....
Black band	223, 467	275, 420	....	51, 953
Hematite	698, 148	657, 181	40, 967	....
Magnetic iron-ore	10, 415	9, 277	1, 138	....
Limonite, (bohnerz)	223, 986	240, 692	....	16, 706
Specular iron-ore	353	....	353	....
Total	3, 555, 005	3, 671, 264	....	116, 359

41. The above table shows the nature of the ores and the quantity raised in Prussia, during the years 1872 and 1873, with the increase and decrease. The total product of iron-ores during the year 1874 is given at 2,090,133 metrical tons, valued at about £893,461, a diminution of no less than 1,464,872 tons in quantity, (£776,384 in value,) as compared with the production in 1873.

The following data show the production, estimated value, and number of hands employed in the different government iron-works in Prussia in 1874:

	Production in centners.		Value in thaler.		Workmen.	
	1874.	1873.	1874.	1873.	1874.	1873.
Iron-ores	1, 203, 324	2, 286, 315	187, 049	410, 152	531	518
Pig-iron	368, 276	324, 974	571, 213	760, 651	273	257
Iron castings	173, 026	226, 994	703, 330	1, 128, 745	796	927
Parts of machines	29, 528	41, 250	348, 935	420, 169	366	303
Steel articles	1, 174	890	19, 244	15, 789	16	17

2. The rapid increase in the production of iron and steel for the last ty years is well illustrated by a series of graphic charts on a large le hung upon the walls of the entrance to the German building for ning industry. These charts show in colors the relative product of h year from 1837 to 1871 in millions of kilograms.

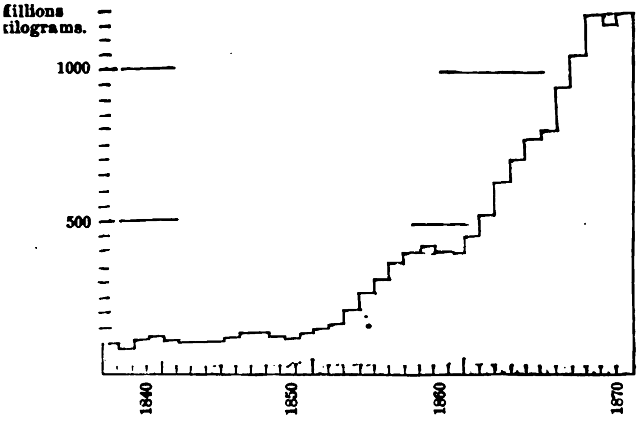

FIG. 47.—Production of pig-iron, Prussia, 1837 to 1871.

The chart for pig-iron shows a gradual increase through each decade, t the chart of steel-production shows a very rapid augmentation of oduct since 1860.

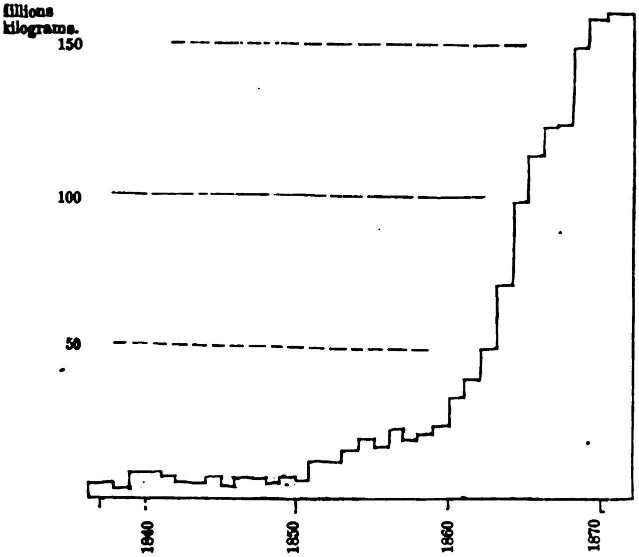

FIG. 48.—Production of steel, Prussia, 1837 to 1871.

Each of these diagrams shows a very considerable fluctuation of production from year to year, but, on the average, a constant increase, highly encouraging to the industry of iron.

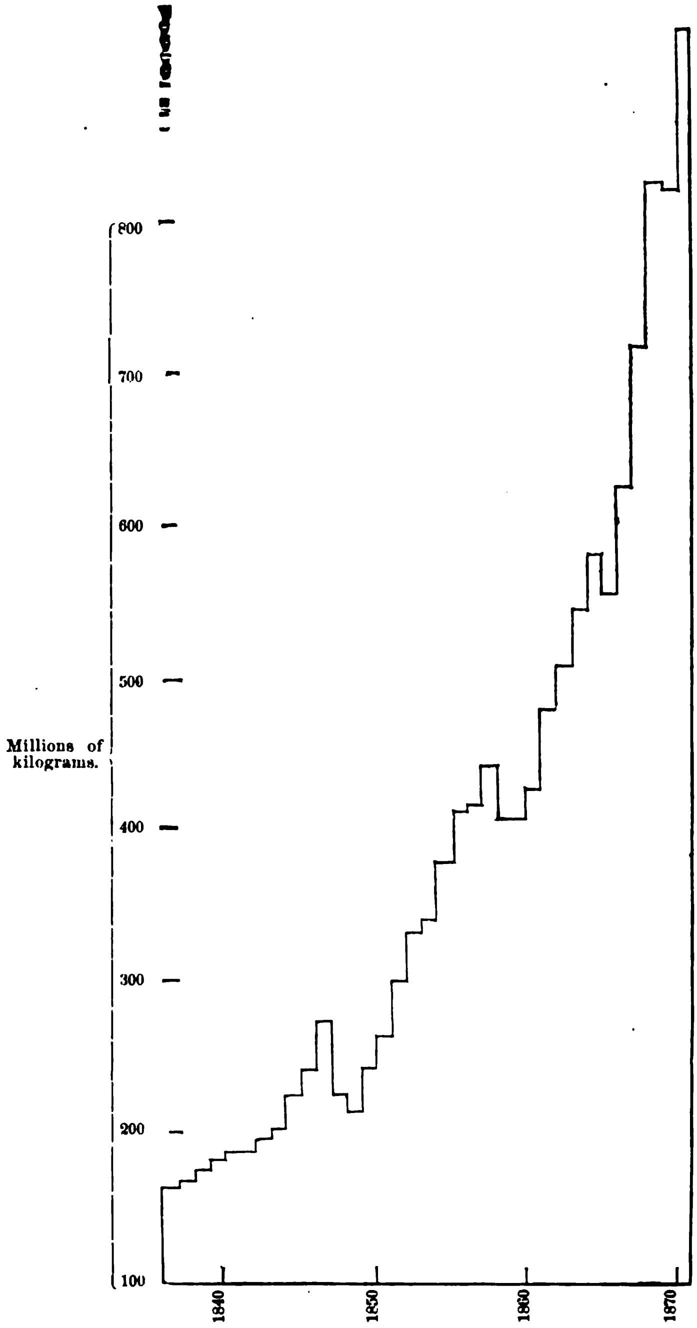

FIG. 49.—Production of bar-iron, Prussia, 1837 to 1871.

The German trade in iron and steel, and manufactures from them, ' considerable, as shown by the customs returns for the year 1871, , as below, the imports and the exports:

	Imported.	Exported.
	Cwt.	*Cwt.*
	11, 849, 410	4, 137, 844
iron	1, 418, 809	1, 212, 885
iron	2, 017, 511	2, 553, 908
	93, 731	161, 349
steel wire	36, 360	161, 127
rought-iron and steel objects	765, 981	1, 225, 188
-iron pipe	138, 011	119, 432
stings	437, 505	496, 231
n and steel-plate	597, 840	323, 557
	70, 105	58, 289
ware	12, 160	22, 558
edles, steel pens, &c	76, 134	22, 477
tal	5, 664, 747	6, 357, 001

The number of exhibitors in Group I alone is not less than one ed and seventy-two, most of them being iron and steel works of erable magnitude, but this number includes also exhibits of coal, , lead, zinc, &c. There are, besides, in the section of Group VII Industry) devoted to manufactures of iron and steel no less than indred and fifty exhibitors, but these include many manufactures dinarily classed with iron and steel products.

y a few of the more prominent exhibits, in regard to which notes nade, can here be noticed.

A. BORSIG, UPPER SILESIA.—This firm, with large establish- in Silesia, and also near Berlin, makes a fine display of cast-steel , sections of girders, piston-heads, boxes, and various parts of nery. There are some large and well-forged cranks and connect- ds, large boiler heads and plates, in cast steel, one weighing 480 ams; another 5,300 by 1,500 by 13 millimeters, weighing 950 kilo- . Among the large boiler-plates, (presumably of iron,) two may d for their great size and perfection. The first, 6,400 by 2,200 by meters, weight 550 kilograms; the second, 8,000 by 2,100 by 13 eters, weighing 1,700 kilograms. Two sheets of locomotive-boiler respectively, 7,400 by 1,010 by 30 millimeters, weight 967.5 kilo- , 7,500 by 1,170 by 40 millimeters, weight 2,730 kilograms, received rogress Medal. The central portion of this fine display consists lass case containing the smaller objects surmounted by a stack . There is a monumental pyramid of coal, with a bust of Borsig (?) top. Progress Medal.

se works were established in 1863. There are now (1873) 4 furnaces, 40 puddling-ovens, 21 heating-ovens, 3 annealing-ovens, melting-ovens, and 2 heating-ovens. They produced in 1872, with workmen, 400,000 hundred-weight of pig-iron, 26,000 hundred- t castings for the use of the works, 300,000 hundred-weight of iron, 26,600 hundred-weight steel for the German market. Open- steel by Martin's process is a specialty of these works.

46. Dillinger Company.—The Dillinger Stock Company makes a fine display of rolled plates, of large size and of all thicknesses, manufactured of superior charcoal-iron. These sheets of iron comprise reservoir-iron, bridge-sheets, locomotive-boiler plate, and ordinary sheet-iron and tin-plate. One sheet of reservoir-iron weighs 2,130 pounds, and measures 6,500 by 1,900 by 11 millimeters; a bridge-plate measures 150,000 by 1,000 by 9 millimeters, and weighs 2,100 pounds. A locomotive-plate 4,100 by 1,900 by 19 millimeters. Button-iron is shown in sheets 456 by 305 by 0·26 millimeters. Some of the sheet-iron is so thin that 38½ sheets are required to make a thickness equal to one millimeter. Buckled plates and corrugated iron are shown in great variety, and apparently of unusually good quality.

This establishment was founded in 1763. In 1872 the production was about 400,000 hundred-weight of sheet-iron, including the tinned and zinked iron. About 2,000 men are employed.

47. Styrum Company, Oberhausen.—The stock company at Styrum, in Oberhausen, Rhenish Prussia, send some very large rectangular and circular boiler-plates, with bar and angle iron of all forms. One boiler-plate measures 3,770 by 2,305 by 13 millimeters, and weighs 1,025 kilograms. The circular boiler-head is 2,550 millimeters in diameter and 15 millimeters thick, and weighs 625 kilograms.

These works were established in 1857. In 1872 the production, with 650 workmen, was about 300,000 hundred-weight. There are 40 puddling-ovens, 20 heating-ovens, and 11 rolls.

48. Iron shoes for railway-brakes.—The brothers Glockner, of Tschirndorf, near Halbau, in Silesia, send a variety of forms and sizes of brake-irons for the use of railways. They have agents in England, Russia, Bavaria, Austria, and Hungary. This concern makes a specialty of steel castings, and produced in 1872 7,000 hundred-weight with 95 workmen and two cupola-furnaces.

49. United Königs and Laurahütte.—The furnaces and rolling-mills of this company were represented by a conspicuous stack of bar-iron, rails, rods, and sheet-iron tastefully arranged upon a pedestal surmounted with an iron crown, and bound around with a sheet-iron band, tied in a bow-knot. This was placed in the rotunda. The bars and rods were variously twisted and tied into knots to show their toughness and strength.

There are 7 blast-furnaces at Königshütte, and a rolling-mill, besides works for Bessemer steel. At Laurahütte there are eight furnaces, six of which produced 35,000 tons of pig-iron in 1872.

IRON-WIRE INDUSTRY IN WESTPHALIA.

50. The Westphalian Union Joint-Stock Company in Hamm, on the Lippe, (*Westfälische Union Actien-Gesellschaft für Bergbau, Eisen, und Draht-Industrie,*) is a recent incorporation representing several distinct establishments, which, as united, is claimed to be the largest undertak-

ing in the world for the manufacture of iron and steel wire. Over 2,800 men are employed, and the total annual production of manufactured ware, exclusive of pig-iron, is about 84,000,000 pounds, and is increasing.

Until recently this great industry was in the hands of a few private firms. The chief market for their production was in the cities of Iserlohn and Altena, and their vicinity, for the manufacture of needles. A number of small mountain-streams supplied the power for grinding and polishing the needles. But the rapid spread of the electric telegraph and the substitution of iron for copper wire in its construction completely changed the market and revolutionized the wire-industry of this region.

Another very considerable demand for iron and steel wire grew out of the use of wire-ropes in mining-operations and the greatly extended consumption of wire-nails. Wire-nails for many years were of small size, not much larger than carpet tacks or brads, but now they are made of almost all dimensions, up to one-quarter of a meter in length and three-quarters of a centimeter in diameter. They are largely used in building, are made by machinery, and are very cheap. They have driven wrought nails, excepting only horseshoe-nails, from the market.

Another important consumption of the wire made in the works of the Westphalia Union is in the manufacture of rivets, screws, springs, and of wire-cloth and lattice-work. It is largely used also for wire-cordage for ships' rigging, for teledynamic cables, and for suspension-bridges.

These are some of the many uses of wire cited by the company in the brochure which they print in German descriptive of their works and production. They draw attention to the fact that the quality of wire is not of so much importance in their estimation in the manufacture of nails and screws as in the manufacture of needles, rivets, and wire-rope, and sometimes, also, of telegraph-wire. These latter require considerable hardness and tensile strength in the wire. For the production of wire-rope, and also telegraph-wire, it is important that the wire be in as long pieces as possible. The company claims for its products a world-wide reputation, and gives a statement in some detail of their distribution and uses in several countries, from which the following is condensed.

51. The high reputation which the Westphalia wire-industry has obtained comes from the fact that the different works have made the manufacture of wire a specialty, and by long experience have been able to satisfy the demands of the needle-trade as regards quality.

The Westphalia wire-industry had also better opportunity for the selection of suitable raw material than other localities, and the works could produce blooms directly from the pig, which could be rolled into wire in a second manipulation without the manufacture of a costly intermediate product. The importance of these advantages over other localities, and the care exercised in the manufacture, enabled the Westphalia wire-industry to overcome the competition of the English and French. Westphalia telegraph-wire is used in various submarine cables; stretches over the great Russian Empire; withstood competition with the English wire used by the English government in the East Indies, for which tests were required which other manufacturers considered unattainable. It is used by the Brazilian government; it was well known in the Parisian market before the French war, and obtained this market afterward, and is used by the Prussian and German government telegraphs. In the Franco-Prussian war of 1870–'71, the great demand for field-telegraph wire was supplied by the firm of Cosack & Co., now the Hamm division of the Union. It is not strange, therefore, that this wire-industry, which was previously in the hands of a few firms, drew the attention of capitalists, and a joint-stock company was formed, in order to secure more capital and a consolidation of interests against competition. Four of the most important works of the Westphalia wire-industry now united under this firm will be noticed in succession.

52. Hamm Division, (formerly Cosack & Co.)—Annual production, about 28,000,000 pounds of rolled wares. The works are situated on and connected with three principal railways, with an area of about thirty acres. The manufactures consist of the following chief products: Bar-iron and rolled wire, drawn wire, especially telegraph-wire, wire for wire-ropes, &c.; wire-tacks, springs, boiler and bridge rivets, and carriage-axles. The plant of these works consists of 30 puddling-furnaces, including 2 "Schrott ovens," 9 heating-ovens with blast, 38 steam-boilers, 3 steam-hammers, 1 lift-hammer, and 6 lines of rolls, 2 of which are for bloom-iron, 2 for bar-iron, and 2 for rolled wire, besides the ordinary shears and saws. There are 14 driving-engines, besides the necessary accessory engines, giving altogether about 450 horse-power, with water-pumps, steam-pumps, &c. The rolled wire produced is for the most part further worked in 2 drawing-mills and a tack-shop. In a rivet-shop, boiler and bridge rivets are made in 7 machines; 6 hammers and 20 lathes and drills serve for the manufacture of axles. The establishment possesses 1 iron-foundery with 3 cupola-furnaces and 1 reverberatory furnace, 1 machine-shop, 1 apparatus for zinking fourteen wires at the same time, 1 factory for green vitriol, (sulphate of iron,) 1 factory for fire-brick, and 4 limekilns.

53. Nachrodt division, (formerly Ed. Schmidt.)—This has an are of about 150 acres and railway connection with the "Bergisch-Märkisch Railroad, with a solid bridge over the Linne. Annual production, abou 24,000,000 pounds of finished goods. These works have the advantag of a very important water-power of the Linne at their disposal, and, i deed, the works are run by the following: 1 water-wheel of 100 hors power, 1 water-wheel of 60 horse-power, 1 Köchlin turbine of 13 horse-power, 1 second turbine of 100 horse-power, 1 third turbine, fo running the drawing-shop, of 10 horse-power, making a total of 40

orse-power. Such an available water-power represents a considerable apital in comparison with the cost of steam-engines and boilers, with xpenses for repairs, and the consumption of coal. These works were, herefore, in a situation, being alongside the rolling-mill, which, by the aste heat, afforded enough steam for the finishing of the product, to ake up some manufacture which required greater power than the heat rom the gas-furnaces produced, as is the case with the manufacture of hin plate. Although the manufacture of rolled wire is the most important, these works also produce a considerable quantity of tin-plate as ell as sheet-iron, button-plate, and brass-plate. The plant consists of 1 puddling-furnaces, 7 heating-ovens, 22 steam-boilers, 3 steam-ham- ers, 6 steam-engines, 3 bar and bloom rolls, 2 refined iron lines of rolls, wire line of rolls, 4 pairs of plate-rolls for tinned plate, sheet-iron, and utton-plate, and also 2 pairs of rolls for brass-plate. The manufacture f rivets, nuts, and screws is considerable, and during the last working ear reached about two and one-third million pounds, which yielded a ery good profit. The works possess a foundery, draw-shop, blacksmith- hop, repair-shop, and all the necessary accessories. There are also in rocess of building, 4 puddling-furnaces for utilizing fine wire and plate- aste, 1 bloom-roll, and 1 steam-hammer.

54. LIPPSTADT DIVISION, (formerly A. & TH. LINHOFF.)—Annual pro- uction, about 13,000,000 pounds of finished goods. The puddling and olling mill at Lippstadt produces chiefly wire and wire fabrics, and also erchant iron. The works are connected with the Westphalia Railway, nd possess about twenty-eight acres of territory in the immediate neigh- orhood of the station. The puddling and rolling mill contains 12 pud- ling-furnaces and 3 heating-ovens, each oven being provided with a boiler. The works have 3 sets of rolls and 1 bloom-roll, 1 bar-roll, and 1 quick roll for wire; 2 steam-hammers, and 2 small lift-hammers for the manufacture of beaten iron; finally, 1 drawing-mill, with 12 large-sized and 68 medium and fine sized rolls. The drawing-mill and tack-factory at Belecke, belonging to Messrs. Linhoff, have also been added to the property of the company. This has an area of about forty acres, besides water and steam power. The factory contains 46 wire-tack machines, 16 large-size rolls, 8 fine size, and 8 medium size in process of erection. All the shops possess the necessary repair-shops, with lathes, drills, planing machines, &c. The charcoal-furnace at Bericherhütte, in Fürstenthurm, Waldeck, also belongs to the Linhoff Works. This furnace has a daily production of about 40 centners of the best charcoal-iron, of unusual strength, which is especially suited for piano-wire and scraper-wire, but is employed mostly for hard castings, parts of rolling-machines, square and corrugated rolls, puddling-furnace canals, crucibles, &c. This furnace has the right of pre-emption for charcoal in the Fürstenthurm, Waldeck, and possesses 57 shares (out of 128) in a mining concession of 521,750 square "lachter" (fathoms) of a very valuable iron-ore. A railway now built is intended to bring the mine into communication with

the station Bredlar. This railway is conducted by the mine-owners, and was to begin operation in July, 1873.

55. WERDOHL DIVISION, (formerly FRIEDRICH THORNÉE.)—Annual production, about 19,000,000 pounds of manufactured products, such as rolled wire, drawn wire, and springs. To this division belong:

a. The puddling and rolling mill in Werdohl, with 14,000,000 pounds' production, situated immediately by the station, and connected by a side-track with the "Bergisch-Märkisch" Railway. These works have 16 puddling-furnaces, 3 heating-ovens, 16 steam-boilers, 2 bloom-hammers, 1 bloom-roll, 2 wire-rolls, and a repair-shop with roll-drawing apparatus.

b. The works in Uetterlingsen, (wire-drawing mill.)—These are situated on the Linne, a quarter of a mile from the station Werdohl, and have a water-privilege of about 250 horse-power and 1 steam-engine, driving 48 large-size, 22 medium-size, and 130 band and scraper rolls. There are also machines for drawing spring-wire. There are about 2,500,000 pounds of products.

c. The puddling and rolling mill at Einsal, with about 5,000,000 pounds' production, situated half a mile from the station Altena. These works have about the same water-power as those at Uetterlingsen, with 5 puddling-furnaces, 1 heating-oven, 1 lift-hammer, 1 bloom-roll, and 1 wire-roll.

IRON GIRDERS AND COLUMNS.

56.—The finest display of rolled girders and angle-iron of large sizes is made by the Burbach Furnace Company, (*Luxemburger Bergwerks und Saarbrücker Eisenhütten-Actien-Gesellschaft zu Burbach*,) which sends a variety of girders of full length, and elegantly supported upon a pyramidal iron frame, sustained by a special stone foundation independent of the floor of the building. The girders rest upon ornamental brackets, in the form of lions' heads. The following sizes of girders are noted:

18,000×355×142×13 millimeters.
18,000×262× 96× 9 millimeters.
18,000×200×100× 9 millimeters.
18,000×125× 75× 6 millimeters.

I 16,500×400×140×10 millimeters.
⌶ 16,500×250×140×10 millimeters.
⊥ 16,500×200 120× 8 millimeters.
⊐ 16,500×153× 58× 7 millimeters.

The same establishment sends several hollow wrought-iron columns, composite, made by riveting together flanged plates of the proper form; in short, the well-known American Phœnix wrought-iron column, invented and patented by Samuel J. Reeves, president of the Phœnix Iron Company, June 17, 1862.* The specimens here shown are highly creditable to the works, being of large size and well made. The largest (*a*) is square in section, and 12 inches internal diameter; another (*b*) is the same in form, but smaller and longer; and a third (*c*) is simply a flanged girder ⌐. The exact dimensions are below:

---

* Works at Phœnixville, Pa., John Griffen, superintendent.

a. 19,200×280 ×86×18 millimeters.
b. 20,000×163½×70×13 millimeters.
c. 26,000×157 ×96×12 millimeters.

A long round column of similar construction, and very perfect, and remarkable also, as all such columns are, for rigidity, lightness, and strength, is shown in the Belgian section.

Columns of this construction and of greater dimensions than these are no novelty in the United States, for the Phœnix Iron-Works make a great variety of sizes and forms, and can fill orders on demand for columns 100 feet long, and from 3 inches to 3 feet in diameter, composed of segmental pieces, varying from ¼ of an inch to 2 inches in thickness.

For more than ten years this description of column, or post, has been largely manufactured at the Phœnix Iron-Works, and many thousand tons of them have gone into the construction of wrought-iron bridges, viaducts, depots, warehouses, and other structures in various parts of the United States, Canada, Nova Scotia, and in South and Central America. All the top chords and posts of the trusses in the international bridge over the Niagara River, near Buffalo, are made of Phœnix columns. The same can be said of the intercolonial and all the new bridges on the Grand Trunk Railway in Canada, the Augusta bridge, in Maine, the Girard Avenue bridge, over the Schuylkill, the New River and Greenbrier bridges, in Virginia, the three wrought-iron bridges at Rock Island, Ill., and scores of others. Many important viaducts are composed almost entirely of those columns, as the Lyman and Rapallo viaducts in Connecticut; the Lyon Brook, Deep Gorge, and Blockhouse, in New York; Bullock Run and Bank Lick, in Kentucky; the Agua Venagas, in Peru. Many of these structures are of great length and depth, the last-mentioned being 580 feet long, and crossing a gorge 252 feet deep, over which the Lima and Arroya Railroad is carried. The overhead Greenwich Street Railway, in New York City, rests on a continuous line of these columns, though not by any means a good type, owing to their flaring tops and bottoms, made to suit the peculiar notions of the contractor of the railway.

57. The BURBACH WORKS were established in 1816, with four high furnaces. In 1872 there were about 1,550 workmen, and the production was over 1,000,000 hundred-weight of pig-iron, 418,000 hundred-weight rails, and 422,000 hundred-weight of shape-iron. Since 1867 the daily product of the furnaces has increased from 100 to 350 hundred-weight. Double-⊤ girders are the specialty of the works. They also manufacture and exhibit wrought hoops, flanged inward, for lining circular mining-shafts. Some of these are from 10 to 12 feet in diameter, and 5 feet high. One hoop or ring is designed to set upon another, and in this way a high column may be built up.

IRON RAILWAY-TIES.

The Burbach Company also make an interesting exhibition of the different forms of iron they are manufacturing for "permanent way" for railroads by substituting iron for wooden ties. As this method, if extensively adopted, will lead to a greatly-increased demand for iron, it is specially interesting to iron-manufactures, as well as to railroad men, and merits a special notice. The simplest form is a cross-tie, rolled with a raised center and broad flanges, so as to have a firm bearing on the ground.

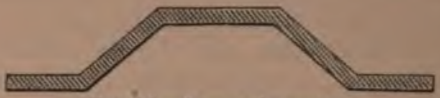

FIG. 50.—Iron railway-tie.

They are about a foot in width and half an inch thick, and appear to be intended to be firmly bedded in the earth without any special kind of filling. The rails with a suitable chair are bolted to the top.

Another form of "permanent way" consists in placing the iron sleepers on ties longitudinally under the rails, not across the track, but with it, in lengths of about twenty feet each, the parallelism and the uniform distance of the rails being maintained by tie-rods at intervals. The form of this iron bed-plate differs from the simple cross-tie above mentioned. It is wider, and is provided with sharp flanges projecting downward so as to penetrate the ground and hold it securely against side-thrusts. The breadth is 300 millimeters; depth, 60 millimeters from the top to the edge of the flange, equivalent to about 12 inches wide and 4 inches deep.

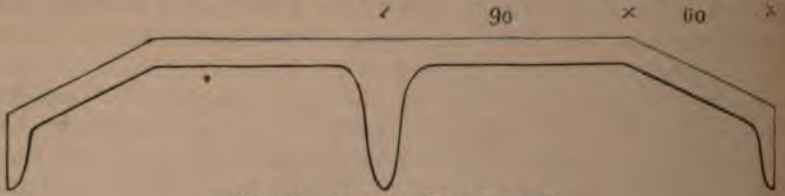

FIG. 51.—Cross-section of iron tie.

58. SCHALTENBRAND'S IRON CROSS-TIE.—C. Schaltenbrand, of Berlin, exhibits his proposed iron railway-tie, a hollow sleeper, filled in with sand or concrete, and to which the rail is attached by bolts. As early as 1870 Schaltenbrand described his method of making a railway entirely of iron, in a lecture at Cologne, and endeavored to prove that the wooden ties so universally used in railway-construction can be replaced by iron ties with profit. He stated eleven conditions essential to first-class construction which are realized in sleepers made wholly of wrought iron. He then thought, and still thinks, that iron ties are destined to replace wooden ones at no distant day, particularly where wood is growing scarce and dear and iron more abundant and cheaper. The relative economy can be easily ascertained by trial of the iron ties alongside of the ordinary wooden ones.

The ties, as exhibited, consist of plate-iron rolled or bent into the form indicated by the cross-section annexed, with a bottom-plate bent upward at the edges so as to catch and hold the edges of the upper plate.

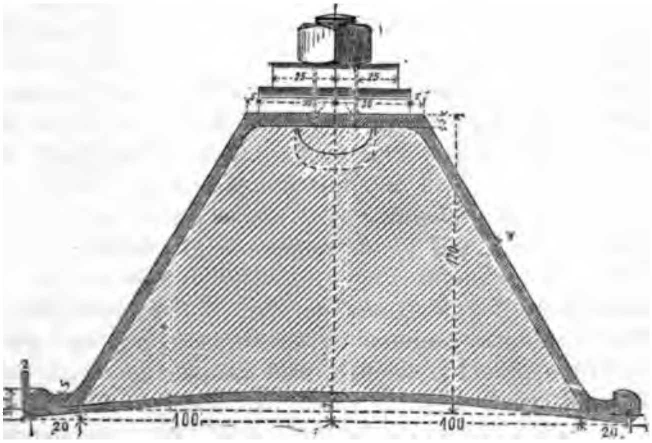

FIG. 53.—Section of iron railway-tie.

A flat piece of iron is rolled or welded upon the top, and the rail rests upon this. The method of attaching the rail is in this instance by clamps pressed firmly upon the foot of the rail on each side by bolts, as shown in the cross-section of the rail appended, but this is unimportant, as other methods of securing the rail to the tie may be adopted.

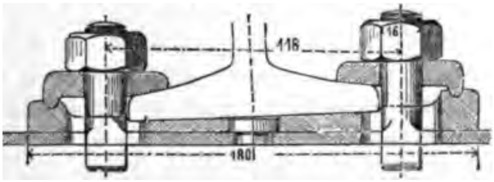

FIG. 54.—Cross-section of the foot of rail and the clamps.

The total breadth of the tie is about 10 inches; the height to the bottom of the rail 5 inches, and the thickness of the iron plate three-sixteenths of an inch at the sides and a trifle thicker at the top. The dimensions in millimeters are: breadth, 140 millimeters; height, 120 millimeters + 10 millimeters; thickness, 4 millimeters and 5 millimeter. The extreme length of the tie is 2,500 millimeters and the width of track 1,435 millimeters.

The tie is laid down before being filled in. The inventor proposes for filling either sand, loam, or sand into which small stones are crowded to make the filling firmer, or beton. These materials are to be rammed in from the ends, and the openings are closed finally by a tile of the proper form. It is also suggested that tiles or "shape-bricks" may be made to answer for the filling.

286 steam-engines, viz:

Number	3	57	46	16	17	6	1	4	38	4	21	16	3	22	5
(each, H.P.	2,	4.	6.	8.	10.	12.	13.	14,	16.	18.	20,	23,	25,	30,	35,

Number	2	4	4	2	3	1	5	1	1	3	1
(each, H.P.	40,	45.	60.	80.	100,	120.	150.	200,	500,	800.	1000,

(representing altogether nearly 10.000 H. P.)

1056 machine-tools, viz: 362 turning-lathes; 82 shaping-machines; 195 boring-machines; 107 planing-machines; 42 punching and grooving machines; 32 pressing-machines; 63 grinding-machines; 31 glazing and polishing machines; 142 machines of different kinds.

In the year 1872 there were consumed:

Coals, 500,000 tons; coke, 125,000 tons; water, 113,000,000 cubic feet, supplied from several water-works; gas, 155,000,000 cubic feet, supplied by the gas-works of the establishment for 16,500 burners.

The works are in railway-connection with the Cologne-Minden, Bergisch-Märkisch, and Rhenish lines.

To facilitate the traffic on the works there are—

a. About twenty-four miles railways of usual gauge, with 180 sidings and 39 turn-tables, on which run 12 tank-locomotives of about 16 inches cylinder-diameter, and 530 wagons. Six more locomotives are now in course of construction.

b. About ten miles of small-gauge railways, of 30 inch gauge, with 147 sidings and 65 turn-tables. The traffic on these railways is carried on by means of horses, and of 3 locomotives of 6 inches cylinder-diameter, and 270 wagons. Four other locomotives are now being constructed.

The carriage department comprises, besides, 272 wagons, and altogether 191 horses, of which 60 to 80, are supplied by contractors.

To facilitate the communication between the several workshops, there are 30 telegraph-stations.

A permanent fire-brigade, consisting of 70 men, has also been instituted, who perform at the same time police-duty. There are 166 watchmen besides.

The general supply stores, under control of the firm, sell to voluntary purchasers, (*i. e.* to those belonging to the works,) for ready cash, provisions, clothing, drapery, boots, &c., at cost-prices. The receipts at the different stores amount at present to about £11,000 monthly, and are continually increasing.

Under this head may also be named 1 hotel, 3 beer-houses, 1 seltzer-water manufactory, 1 flour-mill, and 1 bakery with 2 steam-engines, producing at an average 85 tons of bread monthly.

Of the dwellings for the officers and workmen, there are for the former 206, for the latter 2,918, either inhabited or in course of construction. At the present moment there are living in these houses, the number of which is being rapidly increased, already more than 8,000 individuals. The existing boarding-houses offer board and lodging to 2,500 unmarried workmen, and other houses of the same description are now being built for the accommodation of 1,600 more.

The arrangements for the accommodation of the sick consist of 1 ospital containing 100 beds, and 1 epidemic hospital with 120 beds, ll under the supervision of physicians especially engaged for the purose.

A sick, burial, and pension fund has also been instituted for the workmen, *i. e.* for all those who receive wages from the firm. The latter conributes to this fund half the amount of the contributions paid in by he members, being, in addition, at the expense of providing pensions nd support for those who have been rendered unfit for work in their ervice, and for the widows of their workmen. The total receipts in the ear 1872 amounted to £16,000, the expenditure to £12,500, and capital n hand at the beginning of the present year (1873) to £19,348.

From another fund, members receive for their families free medical reatment against an annual payment of 3 English shillings.

Finally, the firm has organized a chemical laboratory, a photographic nd a lithographic atelier, as well as a printing and book-binding establishment. In the printing-office there are 2 steam and 4 hand presses in peration.

Besides the cast-steel works near Essen, the firm possesses considerable mining and smelting works, which render the chief works independent of fluctuations in prices, and secure to it a regular and uniform supply of the best raw material. This head comprises;

1. Administration of Krupp's Mines:

a. Coal-pits: 1. Pit "Graf Beust;" 2. Pit "Ernestine;" 3. Pit "Friedrich Ernestine;" 4. Pit "Hanover;" as well as one-third in the Concessions "Humboldt" and "Diergardt" on the left bank of the Rhine.

b. Iron-ore mines: 1. In the mining-districts "Kirchen," "Daaden," "Siegburg," "Hamm," "Neuwied," together 64 mines, (No. 1 to 64;) 2. In the mining-districts "Wetzlar," "Weilburg," "Dietz," "Oberhessen," "Rheinhessen," and "Dillenburg," together 294 mines, (No. 65 to 358;) 3. In the mining-districts "Hamm a. d. Sieg," "Wied," "Unkel," "Coblenz," "Ründeroth," together 56 mines, (No. 359 to 414.) Total number of mines 414, with an area of more than 239,200,000 square yards.

The firm F. Krupp possesses, finally, important concessions of excellent iron-ore beds in North Spain, whence it is intended to import annually up to 300,000 tons of ore for the production of cast steel. To facilitate the importation, a railway in Spain nearly eight miles long, as well as several steamers, is already in course of construction.

2. The administration of Krupp's Smelting-Works comprises:

a. The Sayner and Oberhammer Smelting-Works, containing two blast-furnaces, one of them fed with charcoal. Both of them produce daily about twenty tons of "spiegeleisen" and "charcoal spiegeleisen." An iron-foundery and a machine-manufactory are connected with the Sayner Works.

b. The Mülhofer Smelting-Works on the Rhine, connected by a branch line with the Rhenish Railway, terminating at the Engers Station, and containing 4 blast-furnaces (3 of them the latest Scotch construction) with pneumatic lifts. Each of them produces daily about 45 tons of spiegel, Bessemer, and fine iron.

c. The Hermanns Smelting-Works on the Rhine, near Neuwied, also connected by a branch line with the Rhenish Railway, has at present only one blast-furnace in operation; two others are, however, in course of construction.

d. The Bendorf Smelting-Works with one blast-furnace of an older pattern, are at present not in operation.

e. The Johannes Smelting-Works, formerly the property of the German-Dutch Joint-Stock Company for Smelting and Mining, near Duisburg on the Rhine, produce daily, in four blast-furnaces, from about 140 to 160 tons. The construction of six more furnaces has been commenced, and the works are in connection with the Rhenish and the Bergisch-Märkisch Railway.

These works have also 140 coke-ovens in operation, and 120 more in course of construction.

Krupp's smelting-works produce, accordingly, at the present time, with eleven blast-furnaces, nearly 10,000 tons pig-iron per month.

60. Catalogue and description of the objects exhibited:

(1.) One crucible cast-steel block, (1,800 crucibles each containing about 60 pounds,) 54 inches octagonal, weighing 52,500^{k} = 52½ tons.

This casting, originally cylindrical, has been reduced to the present octagonal form by forging under a 50-ton hammer to illustrate the malleability of the material. Cuts were made in four different places, while in a red-hot state, to show, when broken off later, the density and soundness of the cast steel. This block, of gun-metal quality, is intended for the body of the gun of 37^{cm} (14 inches) caliber, and receives the required form by further forging.

In London, 1851, the firm exhibited a crucible cast-steel block, weighing 2,250^{k}. = 2¼ tons, and received the only council-medal awarded in the cast-steel department; in Paris, 1855, a block of 10,000^{k}. = 10 tons; in London, 1862, a block of 20,000^{k}. = 20 tons; in Paris, 1867, a block of 40,000^{k}. = 40 tons.

All articles produced in the establishment, with exception of the disk-wheels and crossings, which are cast in molds, are forged and wrought by tools from similar more or less heavy castings of circular cross-section.

(2.) One locomotive straight axle of crucible cast steel, in the forged state, (pattern of the Northeastern Railway, in Switzerland.)

(3.) One forged tender-axle of crucible cast steel, (pattern of the same railway.) The body of this axle is forged complete under the hammer, and requires no further workmanship.

(4.) Six carriage-axles of crucible cast steel, forged according to the dimensions approved by the German railways. The body is, in the same manner, forged complete under the hammer. Production in 1872 of unmounted axles in the forged and finished state, 16,450 axles.

The first extensive trials with Krupp's cast-steel axles were made in the year 1850, at Borsig's works, Berlin, by a commission appointed at a meeting of German railway-engineers, (pamphlet by Landbaumeister Dihm, Berlin, 1850, printed by J. Petsch.) Although the trials were very favorable, Krupp's cast-steel axles were not generally adopted until the year 1861 and 1862. The production increased, however, rapidly, so that the firm supplied, in 1865, more than 11,000, while the supply during last year (1872) exceeded 16,000 axles.

(5.) Two unwelded rings of crucible cast steel, forged from solid blocks by making a cut in the middle and opening them out under a hammer. In accordance with this method of manufacture, patented by the firm in 1853, the railway-tires receive the required dimensions and sections by rolling, as shown by—

(6.) Two samples of tires, ready rolled and complete up to turning. Also, one tire ready turned. Production in 1872, more than 45,000 tires.

Up to the year 1853, only welded-iron and fine-grained iron tires were manufactured. Krupp's establishment was the first that introduced the unwelded cast-steel tires for use on railways, and caused them to be generally adopted. Since the expiration of the above-named patent, this method of manufacture has, in principle, been imitated by all works manufacturing cast-steel tires.

(7.) Two unwelded angle-rings of crucible cast steel, for steam-boilers, made in the same manner as the tires.

(8.) Two coupling-rods and two connecting-rods, forged from crucible cast steel. Pieces of machinery of this description are supplied by the works in the forged state only, as here shown.

(9.) Four piston-rods, forged from crucible cast steel. (Pattern of the Central Railway, in Switzerland.)

(10.) Two slide-bars of crucible cast steel, in the forged state.

(11.) Two pistons, forged from crucible cast steel. (Pattern of the Niederschlesisch-Märkisch Railway.)

(12.) One locomotive crank-axle of crucible cast steel, with single, and one with double-bearings. Both axles are in the finished state.

Those crank-axles, which were supplied to the French Orleans Railway during 1857, 1858, and 1859, have, up to the present year, run over 500,000 kilometers, (312,000 miles,) and are still in good working order.

(13.) One locomotive eccentric crank, and one driving-wheel crank, both of crucible cast steel, in the finished state. These pieces of machinery are supplied by the works in the rough-turned or finished state.

(14.) One set of locomotive and tender axles, pattern for engines C. IV of the Northeastern Railway, in Switzerland, consisting of—

a. One driving-axle of crucible cast steel, ready fitted with tires, cranks of same material, spoke-wheels, nave included, of wrought iron, and cast-iron counter-weights. Weight, 2,160^k = about 43 cwt.

b. Two coupling-axles of crucible cast steel, ready fitted with tires and crank-pins of the same material; spoke-wheels, nave included, of wrought iron, and cast-iron counter-weights. Weight of each, 1,900^k = about 38 cwt.

c. Two tender-axles of crucible cast steel, body forged, ready fitted with tires of same material, and spoke-wheels, nave included, of wrought iron. Weight of each, 1,200^k = about 24 cwt.

Production in 1872 of complete sets of locomotive and tender-axles, 475.

(15.) Two carriage-axles of crucible cast steel, body forged, ready fitted with tires of same material, and spoke-wheels, nave included, of wrought iron. Weight of each 950^k = about 19 cwt.

Axles and tires according to the dimensions approved by the German railways.

Production in 1872, 4,650 sets.

(16.) Two carriage-axles of crucible cast steel, ready fitted with disk wheels, cast in molds, of same material. Weight of each, 1,000^k = about 20 cwt.

Production in 1872, 4,340 sets.

(17.) A collection of spring-steel fractures and cross-sections of spring-steel. This steel is supplied in bars of any section not less than 10^{mm} thick and 65^{mm} wide.

Production in 1872, 3,000,000^k = about 3,000 tons.

(See fractures and cross-sections under No. 26.)

(18.) A collection of cast-steel springs for locomotives, tenders, and carriages:

a. Two locomotive-springs with ten flat leaves, welded links, and bored bolt-holes; two of the same with 14 flat leaves, with welded links and bored bolt-holes.

b. Two collision-springs with 9 flat leaves; one with 13 ribbed leaves.

c. One tender spring with 9 flat leaves.

d. One passenger-carriage spring with 5 ribbed leaves and rolled eyes; one with 6 flat leaves and rolled eyes; one with 7 flat leaves and welded eyes.

e. One luggage-wagon spring with 5 flat leaves and rolled eyes; one with 6 ribbed leaves and rolled eyes; four with 7 ribbed leaves and rolled eyes; four with 8 flat leaves and rolled eyes.

Production in 1872, 38,600 springs.

(19.) One reversible double crossing of crucible cast steel, cast in mold and ready to be laid down. (Pattern of the Cologne-Minden railway.) These crossings have been introduced on many German and transatlantic railways.

(20.) Bessemer-steel rails:

The manufacture of these rails is illustrated by a Bessemer casting from which octagonal blocks are forged, as shown by the exhibited samples.

These blocks then receive by rolling the required form for rails, as also shown, are cut off according to weight, and rolled to the prescribed section; two rails rolled in this manner, the ends of which are not cut off, are also exhibited; two rails ready cut and punched according to the Cologne-Minden section V; one for Cologne-Minden switches; one for Oberschlesisch switches.

The annual production of the works of steel rails has increased from 100 tons to 50,000 tons in 1872. This increase is no doubt the best proof of the favorable results obtained from the use of steel rails on railways, and it may be assumed that these rails are now generally introduced.

Besides the manufacture of steel rails for locomotive-railways, the manufacture of those of smaller sections, from 11 to 22 pounds per yard, for mining purposes, has also considerably increased.

Production in 1872, 2,000 tons.

Here follows a collection of rail-fractures of different kinds.

(21.) Two switches of Bessemer steel, (section of the Oberschlesisch and Niederschlesisch-Märkisch Railways,) ready planed, as same are supplied by the works, also in the finished state.

(22.) One double crank-shaft of crucible cast steel, forged also from a solid block and finished, for a transatlantic steamer. Weight, $9{,}000^{k}$; length, 7.650^{m}; diameter, 0.38^{m}.

(23.) One trunnion-hoop, unwelded, of crucible cast steel, in the forged state.

(24.) 2 pressed sides for field-gun carriages, of cast steel, 6^{mm} and 10^{mm} thick.

(25.) Rolls and rolling-machines:

The rolls and rolling-machines exhibited illustrate the most usual forms and dimensions used in this branch of manufactory, one of the oldest of the establishment.

1. 1 pair of rolls, A, 65 by 40^{mm}.
2. 1 pair of rolls, B, 78 by 52^{mm}.
3. 1 pair of rolls, C, 157 by 105^{mm}.
4. 1 pair of adjusting-rolls, 95 by 148^{mm}.
5. 1 pair of rolls for mint purposes, 210 by 210^{mm}.
6. 1 roll for manufacturing percussion-caps, 61 by 72^{mm}.
7. 1 pair of rolls, polished, 420 by 462^{mm}.
8. 1 pair of rolls, to be engraved for rolling spoons.
9. 1 pair lace-rolls, polished.
10. 1 rolling-machine, A, with rolls 65 by 40^{mm}.
11. 1 rolling-machine, B, with rolls 78 by 52^{mm}.
12. 1 rolling-machine, C, with rolls 157 by 105^{mm}.

For goldsmiths:

13. 1 tinsel-rolling machine, 157 by 52^{mm}.
14. 1 lace-rolling machine, 40 by 210 to 58 by 126^{mm}.

All rolls being hardened, excepting those for rolling spoons.

(26.) A collection of fractures of hardened tool-steel, as well as various other fractures of manufactured articles, such as axles, tires, crossings, and disk-wheels; mint-dies with polished surface.

(27.) A series of various classes of ore, pig-iron, and pig-steel iron, from the mines and smelting-works of the firm, used in the manufacture of steel.

61. *Artillery material.*—The guns are manufactured from crucible cast steel, of a quality especially adapted for the purpose, and are, those of the smallest calibers excepted, constructed according to the built-up system. All guns have Krupp's round wedge.

The naval and coast-gun carriages are generally manufactured from wrought iron; only particular parts, such as the axles, axle-trees, cylinders, and piston-rods of the hydraulic buffer, and the slide-rollers of the coast-gun carriages, being made of cast steel. Cast iron is only used for small truck-wheels.

(28.) $30\frac{1}{2}^{cm}$ gun on coast carriage.—Caliber, 305^{mm}; length of gun, 6.7^{m}; length of bore, 5.77^{m}; weight of gun with wedge, $36{,}600^{k}$; preponderance, 0.

The gun has 72 parallel grooves, with 4.5^{mm} width of lands, and a uniform twist of 21.79^{m} in length.

Weight of charged steel shell, 296^{k}; weight of charge, (prismatic powder,) 60^{k}; initial velocity, 465^{m}.

Weight of charged common shell, 257^{k}; weight of charge, (prismatic powder,) 50^{k}; initial velocity, 460^{m}.

The carriage is intended for earth-parapets of 1.9^{m} height, and has a height of 2.380^{m}. To check the recoil, an hydraulic buffer is used. The running-out of the gun after discharge is self-acting.

The projectile is lifted by means of a movable crane with windlass, which is arranged on the right-hand side of the slide, and brought on to the bottom of the gun.

The elevation (+ 17°, — 7°) is taken by means of a toothed elevating-arc on the upper part of the carriage. For training, the end of the slide is provided with a chain-gear.

By this apparatus the gun can be very easily and quickly served.

To run-in the gun, a rope-windlass may be placed, if necessary, on each side of the slide behind.

	Kilograms.
Weight of carriage	5,650
Weight of slide	15,350
Total weight	21,000

A $30\frac{1}{2}^{cm}$ gun of the foregoing description was tried in the month of February, 1873, in the presence of a commission of Prussian and Austrian artillery officers, with 5 rounds of 20^{k}, 7 rounds of 40^{k}, 6 rounds of 50^{k}, 207 rounds of 60^{k}, 5 rounds of 65^{k}; charges of prismatic powder, and with solid shot weighing from 300 to 305^{k}. The gun was after this trial, with exception of slight gutterings (*Ausbrennungen*) in the chamber, perfectly uninjured and ready for further trials, which are to take place on the lately-acquired practice ground of the establishment, $7{,}000^{m}$ in length, as soon as it can be properly prepared for the purpose.

The carriage was, at the end of the trial, also uninjured, excepting a very trifling crushing of the points of the wedge-rails on the girders of the slide.

(29.) 28^{cm} howitzer on coast-carriage.—The gun is constructed for being placed in coast-batteries. Caliber, 280^{mm}; length of gun, $3,200^{m}$; length of bore, $2,520^{m}$; weight with wedge, $10,000^{k}$; preponderance, 0.

The gun has 72 parallel grooves, with 4.5^{mm} width of lands, and a uniform twist of 11.2^{m}.

Weight of charged common shell, 199^{k}; maximum weight of charge, 20^{k}. The carriage of the gun admits of an elevation of 75°.

The carriage differs from the coast-gun carriages principally in that the whole of the under face of the slide lies in the platform on firing, so as to extend the impact of recoil over a larger surface. For training, the slide is placed upon rollers, for which reason the rear slide-trucks are put on eccentric axles.

The projectile-crane, training-gear, hydraulic buffer, and self-acting running-out apparatus are the same as in the other coast-gun carriages. The elevating-gear is also similarly constructed.

Weight of the whole carriage, $9,220^{k}$; height, $1,675^{m}$.

(30.) Short 26^{cm} ship-gun on battery-carriage.—Caliber, 260^{mm}; length, 5.2^{m}; length of bore, 4.420^{m}; weight of gun with wedge, $18,000^{k}$. Preponderance, 0.

The gun has 64 parallel grooves, with 4.25^{mm} width of lands, and a uniform twist of 18.2^{m}.

Weight of charged steel shell, 184^{k}; weight of charge, (prismatic powder,) 37.5^{k}; initial velocity, 450^{m}.

Weight of charged common shell, 159^{k}; weight of charge, (prismatic powder), 30^{k}; initial velocity, 450^{m}.

This gun has a carriage for use in a broadside-battery of iron-clads. The carriage differs from the former ship-carriages for similar purposes, principally in that the hydraulic buffer and apparatus for self-acting running-out are contrived similarly to those of coast-gun carriages. The hydraulic buffer is so arranged that the gun, with the upper part of the carriage, can be retained at once on any part of the slide.

The training is effected by a cog-wheel, which works into a cog-racer in the deck, and is moved by a worm-wheel, so as to dispense with an especial brake to retain the gun in the required direction. For elevation, there is arranged on both sides of the gun a cogged elevating-arc; both are, however, moved simultaneously from the left side of the carriage by a hand-wheel. In order to relieve the ship's side in firing, the recoil is partially received from the grooved rollers by ribs on the upper face of the deck-racers, and from a strong hook, which ties the fore part of the slide down to the strong projecting lip of the front racer.

Total weight of carriage, $8,750^{k}$; height, $1,220^{m}$.

(31.) Long 24^{cm} gun on battery-carriage for casemate-ships.—Caliber, 235.4^{mm}; length of gun, 5.23^{m}; length of bore, 4.54^{m}; weight of gun, with wedge, $15,500^{k}$; preponderance, 0.

The gun has 32 grooves, whose breadth increases toward the breech, with a width of lands of 3.9^{mm} at breech and 7.85^{mm} at mouth. The twist is uniform, of 16.48^{m} length.

Weight of charged steel shell, 135^{k}; weight of charge, (prismatic powder) 24^{k}; initial velocity, 430^{m}.

Weight of charged common shell, 118.5^{k}; weight of charge, 20^{k}; initial velocity, 424^{m}.

The gun is mounted on a battery-carriage for casemate-ships. Owing to its position in one of the obtuse angles of the casemate, so as to be capable of firing through a broadside and a bow or stern port, it was necessary to make arrangements for a change of ports. This is done by means of a turn-table, on which the gun rests with the middle slide-supports and the rear slide-rollers, after the fore slide-rollers have been lifted correspondingly by an hydraulic lifting-jack, fixed under the slide for this purpose. To facilitate the unshackling of the pivot-bar on the change of ports, it is divided, and at the joint an easily removable bolt is put on.

To check the recoil, the carriage is provided with an adjustable plate-compressor. A chain running-in-and-out gear is applied on both sides of the slide-end. For training, the pinion of the cog-racer is moved by the same cranks which are used for the above-mentioned chain-gear.

The elevation is taken by means of a cogged elevating-arc.

Height, $1,195^{m}$.

	Kilograms.
Weight of carriage	2,344
Weight of slide	5,466
Total weight	7,810

(32.) Long 21^{cm} gun on coast-carriage.—Caliber, 209.3^{mm}; length of gun, 4.708^{m}; length of bore, 4.106^{m}; weight of gun, with wedge, $10,000^{k}$; preponderance, 0.

The gun has 30 grooves, whose breadth increases toward the breech, with 3.4^{mm} width of lands at breech and 7.3^{mm} at mouth. The twist is uniform, of 14.23^{m} length.

Weight of charged steel shell, 95^{k}; weight of charge, (prismatic powder,) 17^{k}; initial velocity, 430^{m}.

Weight of charged common shell, 79^{k}; weight of charge, 14^{k}; initial velocity, 430^{m}.

The gun is mounted on a coast-carriage of a description similar to that of the $30\frac{1}{2}^{cm}$ gun.

Height, $2,015^{m}$.

	Kilograms.
Weight of carriage	2,090
Weight of slide	5,110
Total weight	7,200

(33.) 21^{cm} siege-gun, with slide-carriage.—Caliber, 209.3^{mm}; length of gun, 3.400^{m}; length of bore, $2,910^{m}$; weight of gun, with wedge, $3,900^{k}$; preponderance, 0.

The gun has 30 grooves, whose breadth increases toward the breech, with 3.7^{mm} width of lands at breech and 7.5^{mm} at mouth. The length of twist is 12.36^{m}.

Weight of charged common shell, 79^{k}; weight of charge, (prismatic powder,) 6.5^{k}; initial velocity, 300^{m}.

The carriage for this gun is a short slide-carriage, in all essential points similar to the coast-carriages. The slide, when in battery, rests in front on the pivot-block, behind on two rollers which can be moved, for the purpose of training, by means of handspikes. The cogged elevating-arc admits of 27° elevation and 6° inclination. The projectile-crane, hydraulic buffer, &c., are similar to the coast-carriages. This gun can be made available for transport. For this purpose a strong axle with large wheels is placed in the axle-supports, after the gun and carriage have been run in on the slide; then the fore end of the slide is raised by means of a lifting-apparatus, which is permanently fixed on the slide, consisting of a screw with worm-wheel gearing; and finally the rear end of the platform is limbered up. The transport rear wheels have a diameter of 2.046^{m} and a breadth of 0.180^{m} in the rim. The distribution of the weight resting on hind and fore wheels is in proportion of 4 to 1. To lighten the transport-wagon, the slide-rollers may be carried separately; the projectile-crane may be turned over. For transport by rail, the limbered-up carriage can be easily placed on a 10-ton luggage-wagon. The bed, made of oak beams and provided with pivot-block and racer, can be carried on an ordinary luggage-wagon. As soon as the gun has been carried to its proper place over the bed in the battery, it is unlimbered, and then the rear slide-rollers are lowered down on the racer by means of a windlass; the slide is afterward let down in front upon the pivot-block, and the transport axle and wheels are removed.

Height in battery, 1.9^{m}.

	Kilograms.
Weight of carriage	922
Weight of slide	1,728
Total weight	2,650
The limbered-up gun with side-arms weighs	8,160
The bed complete weighs	2,080

(34.) Long 17^{cm} gun on upper-deck carriage.—Caliber, 172.6^{mm}; length of gun, $4,250^{m}$; length of bore, $3,780^{m}$; weight of gun with wedge, $5,600^{k}$; preponderance, 0.

The gun has 48 parallel grooves, with 3.5^{mm} width of lands, and a uniform twist of 11.2^{m}.

Weight of charged steel shell, 55^{k}; weight of charge, (prismatic powder,) 10^{k}; initial velocity, 460^{m}.

Weight of charged common shell, 45^{k}; weight of charge, (prismatic powder,) 10^{k}; initial velocity, 465^{m}.

The upper-deck carriage for this gun is to be placed in the bow or stern of iron-clads, and provided with contrivances so as to be moved easily and quickly into a rear position. To check the recoil, a plate-compressor is used. For training, the slide, which usually rests on the supports, is placed on the rollers, for which purpose the rear slide-rollers are mounted eccentrically.

Height, $1{,}020^{m}$.

	Kilograms.
Weight of carriage	1,255
Weight of slide	2,235
Total weight	3,490

(35.) 15^{cm} siege-gun on wheel-carriage.—Caliber, 149.1^{mm}; length of gun, 3.44^{m}; length of bore, $3{,}040^{m}$; weight of gun with wedge, $3{,}000^{k}$; preponderance, 1^{m} from the trunnion, 25^{k}.

The gun has 36 grooves, with 3^{mm} width of lands at breech and 5.5^{mm} at mouth. The length of twist is 9.7^{m}.

Weight of charged common shell, 28^{k}; weight of charge, (prismatic powder,) 6^{k}; initial velocity, 470^{m}.

The carriage for this gun is constructed as a wheel-carriage. The brackets are made of plates and angle-iron. The elevating-screw admits of 35° elevation and 5° inclination. As a peculiarity in this carriage may be named the hydraulic buffer, which, on discharge, checks the recoil to about 1^{m} or less. The buffer-cylinder can be moved vertically, being fastened to the brackets at one-third of their length from behind. The piston-rod can be moved vertically and horizontally, by means of a pivot-bolt connected with an anchor, partly imbedded in the parapet.

Height, $1{,}830^{m}$; weight of carriage, $1{,}845^{k}$.

(36.) Long 15^{cm} gun on ship-carriage.—Caliber, 149.1^{mm}; length of gun, 3.85^{m}; length of bore, 3.43^{m}; weight of gun with wedge, 4.000^{k}; preponderance at the commencement of the rounding of the wedge, 75^{k}.

The gun has 48 parallel grooves, with 3^{mm} width of lands and 9.7^{m} length of twist.

Weight of charged steel shell, 35^{k}; weight of charge, (prismatic powder,) 8^{k}; initial velocity 460 .

Weight of charged common shell, 28^{k}; weight of charge, 6.5^{k}; initial velocity, 465^{m}.

The carriage of this gun is made for broadside use on sloops of war and similar vessels. It is a slide-carriage. To check the recoil, a plate-compressor is used, and a breeching as reserve. The elevation is effected by a cogged elevating-arc, and the training by means of tackles, for which side-eyes are provided on the rear end of the slide. The slide rests usually by supports on the racers; for training, it is lifted upon the rollers.

Height, 0.960^{m}.

	Kilograms
Weight of carriage	1,505
Weight of slide	935
Total weight	2,440

(37.) 12cm gun on ship-carriage.—Caliber, 120.3mm; length of gun, 2.925m; ength of bore, 2.602m; weight of gun, with wedge, 1,400k; preponderance, 100k.

The gun has 18 grooves, whose breadth increases toward the breech, with 2.5mm width of lands at breech and 6.5mm at mouth. The length of twist is 8.42m.

Weight of charged steel shell, 15.5k; weight of charge, (large-grained powder,) 3.5k; initial velocity, 450m.

Weight of charged common shell, 15.5k; weight of charge, (large-grained powder,) 3k; initial velocity, 450m.

The carriage for this gun is a wheel carriage constructed for the main or upper deck of small vessels. To check the recoil, an hydraulic buffer is applied, similar to that of the 15cm siege-carriage. The buffer-cylinder, movable vertically and horizontally, hangs on the pivot-bolt; the piston-rod is fastened to the carriage. A strong breeching is provided as reserve. The carriage rests usually on four rollers; for training, the rear rollers, which are mounted eccentrically, are lifted, whereby the weight is transferred to a training-roller.

The elevation is taken by means of a cogged elevating-arc, which admits of +15° and —10°.

Height, 0.900m; weight of carriage, 895k.

(38.) 9cm field-gun with carriage.—Caliber, 91.5mm; length of gun, 2.040m; length of bore, 1.819m; weight of gun, with wedge, 425k; preponderance, 50k.

The gun has 16 grooves, whose breadth increases toward the breech with 2.5mm width of lands at breech and 6.5mm at mouth. The twist is 4.53m.

Weight of charged shell, 6.9k; weight of charge, (cannon-powder,) 0.6k; initial velocity, 322m.

The gun-carriage has riveted wrought-iron brackets. Weight of carriage, (without accessories,) 546k. The elevating-screw admits of an elevation of +$15\frac{3}{16}$° and 8°.

(39.) 8cm field-gun, with carriage.—Caliber, 78.5mm; length of gun, 1.935m; length of bore, 1.728m; weight of gun, 295k; preponderance, 70k.

This gun has 12 grooves, whose breadth increases toward the breech, with 2.5mm width of lands at breech, and 6.5mm at mouth. The twist is 3.62m long.

Weight of charged shell, 4.3k; weight of charge, (cannon-powder,) 0.5k; initial velocity, 357m.

The carriage for this gun has also riveted brackets. Weight of carriage, (without accessories,) 460k. The elevating-screw admits of $13\frac{5}{16}$° elevation, and 8° inclination.

(40.) 6^{cm} mountain-gun on carriage.—Caliber, 60^{mm}; length of gun, 1.250^{m}; length of bore, 1.130^{m}; weight of gun with wedge, 107^{k}; preponderance, 14^{k}.

This gun has 18 parallel grooves, with 3^{mm} width of lands and 2.10^{m} length of twist.

Weight of charged shell, 2.3^{k}; weight of charge, 0.2^{k}; initial velocity, 300^{m}.

The carriage has wrought-iron brackets, cast-steel axle, and wooden wheels. On the naves of the axle there are conical friction-brakes.

Weight of carriage, 109^{k}; height, 0.660^{m}.

The elevating-screw admits of 21° elevation and 10° inclination.

(41.) Ammunition:

(*a.*) Shells. Forged of crucible cast steel for every one of the exhibited guns; both whole ones and cross-sections.

(*b.*) Common shells of cast iron for all exhibited guns; some in cross-sections, all with complete percussion-fuses.

(*c.*) Models of cartridges and of prismatic powder.

The specific weight of the prismatic powder is, for the 26^{cm}, 28^{cm}, and $30\frac{1}{2}^{cm}$ guns, from 1.72 to 1.76; for those of smaller calibers, from 1.62 to 1.66.

62. BUTTGENBACH'S BLAST-FURNACES.—The brothers Conrad and Franz Buttgenbach, of Neuss, in Rhenish Prussia, exhibited a model and drawings of their new method of constructing blast-furnaces, patented in Austria, France, Belgium, England, and America. The model, about 4 feet high, is very perfect, and is sold to the Imperial Mining Museum at St. Petersburg. Inasmuch as Mr. Buttgenbach presented with the model a full description of his furnace in print, and reported specially upon it to the Iron and Steel Institute, I prefer to present it in full in his own words:

"In 1859, I undertook the management of the Neuss Smelting-Works, situate on the Lower Rhine, Rhenish Province, and there I found a high blast-furnace, then just recently erected, which had not yet been in active operation.

"An engineer, late of the Liegen district, who had seen all the blast-furnaces of that part of the country set up against steep hills, supplied with raw materials brought up to the required level by means of carts and wheelbarrows, and having steam-boilers and air-heating apparatus mostly on a level with the furnace-mouth, when charged with the duty of sketching out a plan for the work above mentioned, in his inability to free himself from the influence of this (old-fashioned) notion, actually projected and caused to be built on a level plane a stack of masonry measuring 40 feet square at its base, by 40 feet in height, rising perpendicularly.

"At the center of this stack was placed the blast-furnace, its hearth being accessible only by means of very narrow embrasures; upon the platform of the furnace-mouth two steam-boilers have been erected, as well as a draught-flue, the idea being, probably, that the descent was to take place contrary to the natural tendency of the gases.

"This stack being altogether too bulky for me to attempt to remove it bodily, I simply contented myself with clearing away as much of it as possible round about the hearth, and in such condition as I then brought it to, our blast-furnace has been continuously at work ever since 1860, under my management. The difficulty of working with a furnace similarly blocked in, but more especially the fact resulting from the experiences of two or three years' operations that the fire-proof facings had completely worn away, impelled me to attempt the construction of a blast-furnace, the heart of which should be readily accessible on all sides, and following up this idea, I built up at our works a blast-furnace 50 feet high and 17 feet in diameter at the boshes.

"In justice to my brother, a metallurgical engineer, I must not here omit to state that, in elaborating and finally determining upon my plans, I had the advantage of his suggestions and valuable advice.

"In 1867, a model of the above-named blast-furnace was exhibited in Paris, and I had the satisfaction, not only of being complimented upon my idea by a great number of engineers of every nationality, qualified to express an opinion on the subject, but of having conferred upon me, likewise, the distinction of an honorable mention on the part of the jury of the exhibition. The articles contributed to the *Revue Industrielle* of the exhibition of 1867 by Professor Jordan, who occupied the chair of metallurgy at the *Ecole centrale* in Paris, have brought my system into notice in France. Since 1867, six French iron-masters have adopted my system, and have constructed 9 blast-furnaces from my plans and in accordance with my suggestions. Both in Germany and Austria my system has likewise been introduced with success at several iron-works.

"The fundamental idea of this mode of construction and the advantages of the system may be summed up as follows, viz:

"1st. The mason-work of the stack is quite independent of the blast-furnace proper. Each ring or course of bricks constituting the hearth, boshes, and inside wall is readily accessible and free from any casing, except as regards a small portion, measuring from 3 to 4 feet in height, at the widest section of the blast-furnace.

"Consequently, the whole of the above several parts are completely bare and easily reached for any purpose required, even while the furnace is in active operation. This feature conduces to the duration of the furnace, for in case of need any injured part can be repaired, even when the furnace is at work.

"2d. The inside wall and the upper part of the boshes being cooled by the atmosphere having access thereto, they remain in their normal condition without wear, and do not become unduly heated at any time, being, therefore, indefinitely kept in a state of preservation, since there never occurs a fusion of materials at this height.

"3d. The hearth, and the lower portions of the boshes, being apt to suffer after a certain time, from the destructive action of the materials in a melting state, may be replaced without any difficulty whatever while the work is going on, so that there is no occasion to apprehend any extinction of the fires so long as the in-wall is not destroyed. If putting out the fires should at any time become necessary, the hearth and the boshes could be renewed without affecting the in-wall injuriously.

"4th. Each particular brick being accessible during the working of the furnace, and the progress of the fire easily ascertained, corrosions can be obviated by cooling down with water thrown on the several parts, or by means of water-vessels or tuyeres wherein the water circulates placed within these parts as far as the inside of the furnace, whereby the wear and tear can be checked.

"5th. The utilization of the gas at the furnace-mouth can be so managed as to make it yield the best results. The pillars supporting the platform of the furnace-top are gas-pipes, and drop into sheet-iron vessels fixed to the summit of the base of the stack, where it slopes away. These vessels are open on one side, so that when filled with water up to a certain height, they can be shut down by means of a valve, measuring a few centimeters square. The gas issuing forth out of the furnace-mouth finds its way into these receptacles, and in its passage through them travels over a large surface of water. Here it deposits the dust, while a great part of the water suspended in the gas, in a state of vapor, is condensed. Consequently, the gas reaches its destination in a highly-purified condition, and may yield the very best results in those parts where it is desired to make use of it.

"The arrangement of the said water-receptacles allows of the withdrawal of the dust or grit deposited while in full working, and in the event of an explosion, the area of from five to six millimeters of the water-column paralyzes, as though it were a gigantic valve, any injurious effects. In point of fact, instead of dreading we rather wish for explosions from time to time, since they serve the purpose of clearing off the dust and grit that may still be clinging to the inner walls of the pipes. Moreover, there is the advantage of confining these subsidiary appliances to a spot on the works which does not in any way interfere with the general progress of the manufacture.

"6th. The gas-pipes being supporters also of the platform surrounding the furnace-mouth or top, render the said platform independent of the blast-furnace proper, and that without involving any special outlay.

"In the first days of this erection, critics expressed a fear that the chilling of the parts thus exposed in this blast-furnace would be achieved only at the cost of a greater consumption of fuel. But, contrary to such apprehensions, experience has amply shown that blast-furnaces, the brick-work of which at the core is in direct contact with the outer air, use less fuel than do those that are protected by strong mason work, or shut in by means of a second inner casing with a lining of sheet-iron; and the opinion expressed by me from the very beginning explains this result. For, in point of fact, a blast-furnace should form at its lower part a smelting-crucible, and it is generally known that every expedient available is brought into use for the purpose of cooling the walls of this portion of the structure. The boshes are a kind of retort, wherein the ore is reduced by means of its contact with the fuel, and the in-wall is like unto the neck of a retort, and in which the ore is prepared by the action of a moderate heat and contact with the reducing gases.

"If the ore sinking into the in-wall section requires a spongy condition, and continues in this condition without undergoing semifusion, it is quite obvious that the effect produced by the gas must be infinitely greater, and that the ore must descend into the zones of the boshes and of the hearth in a much better state of preparation than if the heat of the in-wall had partially converted it into cinder, so that the reducing gas must pass on, incapable of action upon such ore, except superficially. The ore, thus brought into a better state of preparation, must of necessity require less fuel in order to its perfect fusion.

"Moreover, in the event of cinder being formed at the in-wall zone, it will adhere to the walls and produce concretions, which always impede the proper working of a blast-furnace. When the ore sinks with regularity the smelting-process is facilitated, whereby a further saving of fuel is effected.

"The truth of the foregoing assertions has been fully established by the experience of eight years' working at our works. Concretions have never been noticed, and the proportion of fuel required for the furnace, constructed upon the new principle, has always been from 10 to 15 per cent. smaller, *cæteris paribus*.

"When good coke has been used, excellent No. 1 foundery-pigs have been produced from ores yielding 35 per cent., the consumption of coke being in the ratio of 11 parts to 10 part of pig, at a temperature of 350° centigrade, under blast, while in the case of white pig it is one part less of good coke to every part of pig. Touching the fears entertained of undue chilling in severe seasons, the following facts have served to dispel them *in toto*:

"The blast-furnace at the Neuss Works has more than once been suddenly blown out for several weeks, owing to causes quite foreign to its working capabilities. Three of these suspensions occurred during the war in the year 1870–'71, owing to the want of fuel, and no preparatory arrangements were made before any of the said suspensions of work. They lasted during a space ranging between three and ten weeks respectively.

"I did not touch the blast-furnace during any of the periods of stoppage referred to, the most prolonged of them occurring at a time when the thermometer registered 10° to 17° C., and yet when work was resumed the furnace did its work again with surprising regularity. On the last occasion, however, I was obliged to raise up the tuyeres, in consequence of the thickening of the bottom stone.

"For the last two years, the furnace has been blown from one meter and fifty centimeters above the original level. It behaves admirably, producing as much as 50,000 kilograms in twenty-four hours. I cannot conceive of any blast-furnace constructed upon a different principle being capable of withstanding the effect of events such as those detailed above, and yet remaining fit for work. The blast-furnace I am describing has entered upon the eighth year of its existence, and the condition of its core is such, as yet, that one will readily admit the almost certainty of its lasting out double or three times the said number of years, considering that the bricks of the in-wall and of the boshes have, up to the present, lost nothing of their thickness. This may be easily verified, for all the bricks coming to the outer air may be examined at any moment. Their thickness may be unerringly ascertained by piercing the walls with a small pin-drill. The walls, be it borne in mind, are but weak, measuring no more than 2 feet thickness at the base, and 18 inches at the summit of the in-wall.

"This thickness they have not lost during an existence of eight years. Experience has shown, moreover, that, the core of the furnace being exposed to the air, the internal heat produces hardly any effect upon the bricks, either by dilation or contraction. Hearth, boshes, and in-wall were originally fastened together in the Neuss blast-furnace by means of flat iron binders occurring at the third course alternately.

"This precautionary measure appears superfluous. It is over four years ago since I have had the binders removed at the hearth and boshes, as well as at the in-wall, in part; for I perceived that they served no useful purpose, since the cooling down of the bricks prevents expansion altogether. Indeed, the furnace in the parts referred to is just the same as on the day of its erection.

"At Vienna, I have exhibited at the *Deutscher Pavillon für Bergbau, Hüttenwesen*, (No. 8635,) a model of this blast-furnace, in which I have shown the deductions made from an experience of the working, during a period of eight years, of the first blast-furnace of its kind.

"The chief alterations introduced by way of improvement consist in a diminution of the stack to a very great extent, at that part of it which supports the in-wall; this diminution being accompanied, however, by so considerable a sloping away from the center toward the rise of the boshes, that the space around the hearth and the boshes has been still further enlarged, so that it may be considered as perfectly isolated.

"I have also introduced a peculiar description of closed hearth, which admits of ordinary working, as well as working with a closed hearth. I have been using this method for the last six years with the very best results. Its application is very simple indeed, and free from the objectionable features of other known methods, since the work of the bottom of the furnace can be performed, in case of need, without depending upon the mouth of a tuyere for running off the slag.

hearth is closed in by a cast-iron tymp placed in the usual posi-
This tymp arch is cooled by a current of water passing through a
ron fixed in the cast iron.

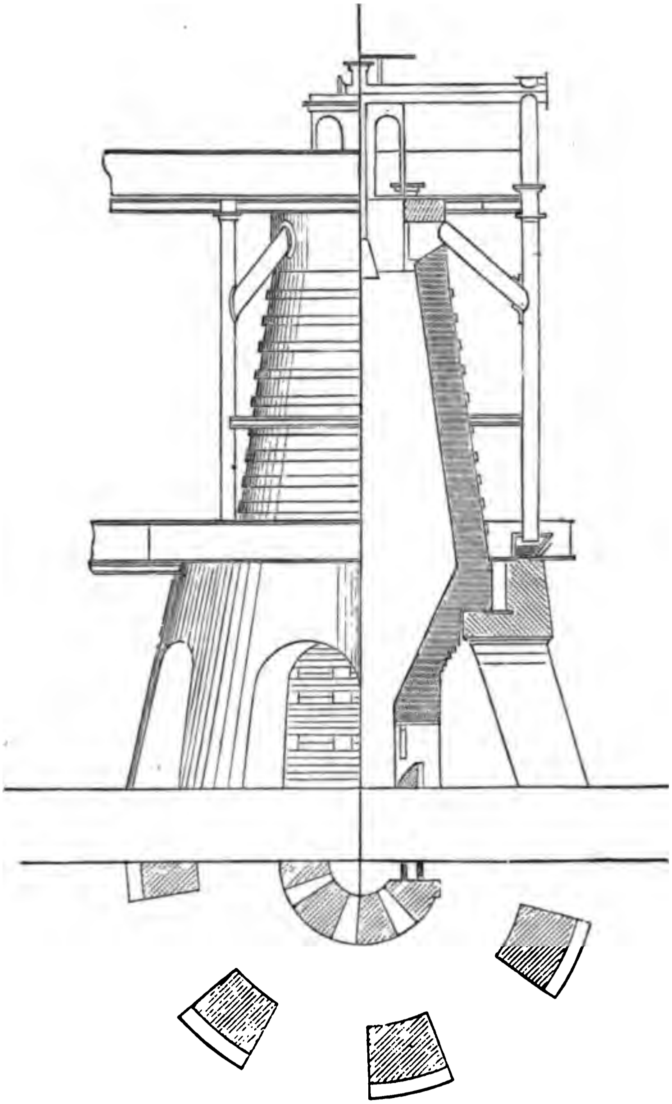

Fig. 55.—Buttgenbach's blast-furnace.—Elevation and section.

the center of this plate there is an aperture or orifice, measuring
uarters of an inch, running almost over the entire height, and the
pipes are situate as near this kind of slit as may be. This slit is
up by means of ordinary clay. A, the upper portion of the slit,

is placed two or three inches higher than the center of the line of the tuyeres.

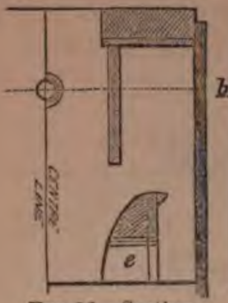

FIG. 56.—Section.

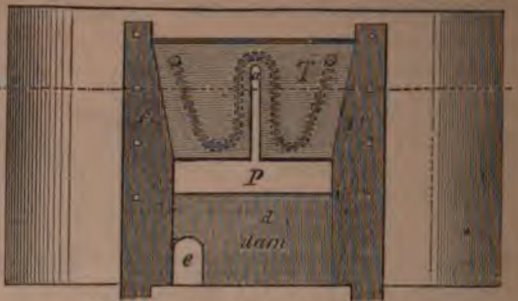

FIG. 57.—Front view of opening.

Front view.

"*b*, level center of the tuyeres; *c*, columns of the breast; *d*, dam; *e*, tap-hole; *p*, space between dam-stone; tymp closed in with clay; T, cast-iron tymp.

"The slag of the blast-furnace ascending above the dam-stone and reaching the level of the tuyeres runs off easily through a hole driven by means of a light steel bar into the said slit; and, since the level of this hole may be altered at will, a means is thus afforded for changing the level at which the slag is run off over a range of 24 inches, which is a very great advantage in itself; but, in addition to that, there is this further facility, namely, that nothing hinders one from tapping the melted ore at this same slit.

"I shall not dwell at length upon the advantages of such an arrangement, but will simply state that during the six years, since I have been making use of it, I have been unable to find any fault with it, and that in my practice it has always possessed all the advantages of the closed breast.

"In the said model, I have also applied three rows of tuyeres, made of gun-metal, overlying one another so that the upper row is two and one-half meters above the first. These tuyeres reach into the interior as deeply as the blast-tuyeres. By this arrangment the walls of the hearth are kept in perfect preservation, and in case of accident the blast may be introduced through the said tuyeres, affording advantages that iron-masters will be able to appreciate without further explanations.

"Practice has shown that this kind of blast-furnace, being readily accessible on all sides and at any moment, is far more easily managed than any other system; which fact practical men will readily admit.

"Over and above the advantages above enumerated, there is another, namely, that the construction of such a blast-furnace must evidently be, and is, in point of fact, much less costly than that of any furnace built upon another principle. It takes much less time to build, to dry, and to fire; in fact, it is a practical elucidation of your English proverb, 'time is money.'

"Let me add, too, that there is nothing to prevent the application of my system to blast-furnaces of all shapes and sizes, and that the largest section would just be the one best adapted for illustrating its great advantages, no less, speaking relatively, than its saving qualities.

"In conclusion, I must say that, to my mind, this system is the most advanced in simplicity of blast-furnace construction."

In reply to criticisms and objections made at the meeting and in the journals, Mr. Buttgenbach addressed a communication to Engineering, as follows:

"At the meeting of the Iron and Steel Institute I had the pleasure of reading a paper about my system of blast-furnaces—a system which was illustrated and described in your number of August 15 last; and I see with satisfaction that this paper is reproduced in your number of August 29, together with a report of the discussion. Your contemporary, *the Engineer*, has also published communications respecting my furnace, and in particular I notice an article in the number of that journal for September 12, expressing opinions adverse to my system. Allow me to say that I shall always be glad to find adversaries to my ideas, as their opposition only gives me occasion to explain these ideas more fully, and, I trust, in a more convincing manner.

"On the occasion of the discussion of my paper at Liége, it was impossible for me to answer thoroughly to the objections made by the members of the institute—first, for want of time, and, secondly, for want of sufficient knowledge of the English language. But having now the reports before me, and encouraged by the interest taken by the English press in my system, I think it due to those who have been present at the meeting, and to the readers of the papers, that I should reply to the various objections raised.

"1. To the objection offered by one speaker, that he did not consider the brick-work of the base practical, and that the use of cast-iron columns is to be preferred, I have to answer that this cannot be an objection to the system as such. I exhibited my model with a base of cast-iron pillars, and with a base of brick-work. My experience shows, however, that a base of red bricks is entirely sufficient, and leaves room enough round the blast-furnace to allow of even the most difficult repairs without opposing the slightest obstacle. I, for my part, would never allow a base to be made of cast-iron pillars, the cost of the latter being four or five times that of a brick-work or masonry base, and the last entirely fulfilling the desired purpose. The adoption of brick-work or cast iron for the base is therefore only a question of economy. The base of brick-work contains 100 cubic meters, while it costs at the Neusser Works only 1,300 francs, and could be constructed in fifteen days.

"2. A second objection raised was that a blast-furnace of the thickness of only one brick would not resist the pressure of the materials in large furnaces like those of Cleveland. I think that quite a false idea exists of this pressure. This pressure is not at all a great one, being partly paralyzed by the state of the minerals, which, by the heat, are caused to adhere more or less together with the coke, without, however, being in a state of semi-fusion or vitrified.

"I have taken away a good part of the bricks of the stack, several meters above the largest section of a blast-furnace, but the mixture remained in the furnace and allowed me to replace the bricks I had taken away without the slightest difficulty. On this occasion I remarked that the bricks had not even lost 3 centimeters after a campaign of seven years.

"For the rest, as supporting what I have said above, I must state that an establishment which adopted my system made, contrary to my advice, the first blast-furnace with a base of cast-iron pillars, and after a few years' experience a second blast-furnace at the same works was constructed with a base of brick-work.

"3. Next, it has been asserted that there are in Cleveland and the North of England blast-furnaces with free-standing shafts.

"I have been over that part of England, and I have not seen *one* blast-furnace where the shaft had a thickness of only one brick; they have all inside a circle of large special bricks, surrounded by a mantle of brick-work, often thicker than the lining. In my furnace the single thickness of bricks is freely exposed to the air, and dilatation by heat being prevented, I am enabled to have a furnace without hoops.

"4. One opponent admits that my arrangement preserves the boshes against the attacks of the fire, but it is said that one could as well repair blast-furnaces such as those in Middlesbrough, which have a lining and a mantle round this of 3 feet or 4 feet thickness. I do not deny that repairs are possible in the latter case, but certainly they are expensive, very difficult, and require much time; every practical man knows that, as soon as one must go below, say 30 feet from the mouth, this becomes difficult work, the more so as the mantle hides the defects of the lining, and one does not know the state of the latter. With an entirely free shaft, on the other hand, one can perfectly well ascertain at any time the state of the bricks, and can easily make repairs, keeping the blast-furnace filled. I think this is a great advantage.

* * * * * *

"7. It was stated that scaffolding does not occur, or ought not to occur, with very hot blast, and especially not where Whitwell's apparatus is employed. I am an advocate of high-blast temperatures, and especially of Whitwell's excellent stoves, but it is not the great heat of the blast which prevents these scaffoldings; these depend upon the quality of the mineral and the coke of the district.

"I could name works in Luxembourg where the blast is heated by Whitwell's stoves, but where, with the small mineral to which I have referred, such dangerous scaffoldings have occurred in a new blast-furnace they feared they should be forced to blow it out. If at the crisis they had had tuyeres available 3 meters higher up, they could easily have got over the difficulty, the more as they had very hot blast.

8. As to the way of conducting the gas, one must not forget that th mineral containing 20 per cent. of water, and of which two-thirds small, (fine,) one has to take precautions quite different to those taken Cleveland, where, though the ore is in lump, I have seen gas-pipes of eet in diameter full of top dust, and which were cleaned with the ut- st difficulty. All these difficulties disappear by my arrangement, d especially all explosions are without any effect—a very important tter when one has to do with wet minerals.

"*En résumé*, all the objections made concern the Middlesbrough dis- ct only, but out of this there exist others too; we, and many other rks, work with mineral of which two-thirds pass into a sieve of 10 les per square inch, containing 20 per cent. of water, and which can- t support any calcining, as getting too easily to powder. Under such cumstances, the Cleveland iron-masters would not have constructed st-furnaces 85 to 90 feet in height, and would have had to take other ecautions than they have to avoid stoppings every week, to manage e difficult cleaning of their gas-pipes, which would soon have been led with dust.

"With materials as used in our district, where we use twenty different inerals always varying, and where coke contains as much as 18 per nt. of cinder, a blast-furnace cannot be so regular, or be so easily naged as a Middlesbrough, and there very often happen disturbances the smelting process.

"The corrosive nature of the mineral containing manganese rapidly tacks the bricks of the blast-furnace, in consequence of which one akes everywhere preparations to prevent that, and I believe that the ree series of tuyeres is the best preservative; for the rest, experience oves it.

"The Middlesboro blast-furnaces endure, it is said, ten to thirteen ars, but certainly they would not do so under the conditions we have meet here. My blast-furnace was erected in 1865, and its condition still such that one will readily admit the almost certainty of its last- g out double or three times its present age.

"Altogether, I find that the observations made by the English iron- asters who condemn my system are too partial, the statements made ading as if the Cleveland district was the only district to be provided ith furnaces, and as if the conditions which exist also existed every- here. This, however, as I have shown, is very far from being the case.

"Even for the Cleveland district I think there are some advantages my system which would be valuable; at least an eight years' experi- nce of my furnace suggests this view to me. I may add, too, that eventeen of my furnaces have been constructed on the continent, and re all at work under almost entirely different conditions. I think this tter is a sufficient reply to the sharp criticism of the *Engineer* to hich I do not want to reply in detail, not being disposed to enter into polemics with a writer who makes inaccurate statements, and then founds arguments on them.

"I did not put up my system as a new invention in every particular of its arrangements, but as a total arrangement it is new. As such it has been acknowledged by authorities, including the owners of the seventeen blast-furnaces built on my system.

* * * * * * *

"NEUSSER IRON-WORKS, (near Dusseldorf,)
"*September* 16, 1873."

OSNABRÜCK IRON AND STEEL WORKS.

63. The Joint-Stock Company of Osnabrück, province of Hanover, founded in 1869, made for the first time an exhibition of its products for comparison with all others in the International Exhibition at Vienna in 1873.

Of the original grand plan of these works, only that part is now finished and this year in full operation which is intended for the production of Bessemer steel and its applications for steel rails, wheel-rims, axles, forgings, &c., and therefore the collection of objects on exhibition is naturally quite limited; but, on account of the origin and method of manufacture of these products, they are none the less worthy of examination.

The group of objects outside of the glass cases consists of—

1st. Bessemer-steel axles, of which three are rough-forged, and serve as a base for a group of wheel-tires; one is a finished forged, and one a finished turned, car-axle, and there is, moreover, one which was bent double in the cold.

2d. Bessemer-steel tires, of which one is finished; one is the rough forging for a tire, and is without a hole; the next one is rough but with a hole; six are rolled and finished, and of diameter from 480^{mm} to $2,420^{mm}$; and one was bent into the form of a figure 8 in the cold.

3d. Bessemer-steel rails, of which four pieces were beat into a spiral form, and one piece was twisted in the cold.

4th. Bessemer-steel forgings, among which are a piece showing the fracture, a large cylinder, two broken pieces of axles, five different proof-pieces from the ends of rails, and two forged ties.

Under the glass cover are—

5th. Various proof pieces of Bessemer steel, among which is a hat with a tassel, made from the end of a tire.

6th. A collection showing the fractures of blocks of rough steel, forgings, tires, and rails.

7th. A rail end and a number of sections.

8th. Breaking proofs of the products obtained by the use of different kinds of iron and coke.

9th. Samples of infusible clays and various infusible substances used he processes of manufacture of Bessemer steel, such as tuyeres, stop- s, funnels, &c.

he production, in tons, of the Osnabrück Iron and Steel Works has n as follows:

	1872.	First half of 1873.
semer rough steel, in blocks	217.42	152.00
ished rails	128.91	125.00
es, axles, and forgings	240.60	100.00

erage laboring force, in 1872, 850 men; first half of 1873, 1,000 men.

here have been employed a Bessemer plant, with two converters and cupola-furnaces; 4 steam-hammers; a rolling-mill for rolling rails; lling-mill for tires; a machine-shop for turning axles; a foundery, h two cupola-furnaces and one flame-furnace; a forge, a carpenter- p, a place for the manufacture of fire-brick, &c.

he thirteen heating-furnaces were heated with gas, which was gene- ed in eight Siemens gas-furnaces.

en engines, together having 1,200 horse-power, were used as motors. e steam was furnished by 24 boilers.

large and a small locomotive were used for transportation.

or some years previous Bessemer steel had been made almost exclu- ely from English hematite pig-iron, and although the German manu- turers had sometimes mixed with it a portion of German pig-iron, it s reserved for the Osnabrück Iron and Steel Works to make the est Bessemer-steel products entirely from German materials, of which neighboring *Georgs-Marien* furnace, with its iron rich in manganese, nishes the larger part; and though from economical considerations e use of English pig-iron is not wholly dispensed with, it has been monstrated that when the production of Bessemer pig-iron equals the mand, the continental manufacturers of Bessemer steel can dispense th foreign products.

The prejudice which has long existed against the employment of Ger- an materials for steel-manufacture, as well as the hesitation of the anagers of railroads to employ Bessemer steel in the construction of ads, cars, &c., have both been overcome, and if Bessemer steel cannot used in the manufacture of all other steel articles, its present im- oved quality allows it not only to be used for rails, but also to com- te most successfully with crucible steel in the general manufacture of es, axles, and other forgings, on account of its greater cheapness. xles made entirely of German pig-iron have been tested by the royal rectors of the Bergisch-Märkische Railroad, and have grandly with- ood the very severe tests of falling weights.

The problem of making such a product from material the behavior of hich in the different processes was uncertain was certainly a difficult ue, but the managing engineer, Mr. Schemman, has by perseverance cceeded in overcoming all the obstacles and difficulties, after many nsuccessful experiments, and has solved the problem.

The converter-linings, the blast-pipes, and all other requisites made of fire-clay which are elsewhere used for the casting of steel, as well as the best of the imported furnace-linings, especially proved themselves to be of inferior quality, and only after all those and other requisites in improved quality were manufactured at the home works could the steel produced reach a perfection which will with difficulty be surpassed. The converter-linings which are made here have sometimes withstood 75 charges, and on an average 50 charges.

Tires of 2,420^{mm} diameter are made from a massive block of steel by punching a hole and rolling.

Rails, which are usually rolled 60 feet long, can, if necessary, be made 100 feet long.

The piece of a heavy shaft exhibited represents some which have been lately made for Westphalia, and which were forged with a fifteen-ton trip-hammer.

The adoption of new and improved machinery at the Osnabrück Steel Works, the fortunate location of the different departments of the works in relation to one another, the increased facilities for production on account of the additional buildings now in process of erection, the making of new products, such as rolling steel, spring-steel, sheet-steel, &c., in connection with the central location at the junction of three railroads, the proximity of furnaces and coal-mines, with property around the works already purchased for further enlargements, secure to these works a very successful future, and especially as local conditions allow cheaper living than is possible elsewhere, and therefore allow steel to be more economically produced.

GEORGS-MARIEN-HÜTTE COMPANY.

64. The Georgs-Marien Mining and Smelting Company, in addition to its very interesting exhibition of ores, iron, mining-maps, and sections of furnaces, published a very full description of the property of the company, and especially of the benevolent institutions founded for the benefit of the workmen. This brochure, in German,* has been freely drawn upon for the following information, translated from its pages.

The origin and development of the works.—The Georgs-Marien Mining and Metallurgical Company was organized in the year 1856, as a joint-stock company for mining iron-ore, coal, and other minerals, and also for the production of iron and other materials from them.

The capital stock is 2,500,000 thalers, of which 1,500,000 thalers were immediately expended, and 650,000 thalers more, making a total outlay of 2,150,000 thalers. Besides this, a loan of 700,000 thalers was contracted, but which is now being rapidly paid. The company bought, in 1856, the mining-privileges of their present property, "Heügel I," a bed of iron-ore, containing 4,815,500 square meters, at Beckerode, near Osnabrück, with the furnaces and machine-works that were upon it. The company also bought various other beds of clay and bog-iron ore in the county of Osnabrück, and received, in 1856, a grant of the coal and iron fields of Glückauf; in 1857, of those in Dörenberg, and in 1858, of those in Hilterberg. These fields together have an area of 48,220,000 square meters. Moreover, in 1865, the company received a grant of the iron-beds of Hügel II, with an area of 3,721,000 square meters.

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* *Beschreibung der Verhältnisse und Einrichtungen der Georgs-Marien-Hütte bei Osnabrück. Ausgestellt unter Gruppe I, Nro, 8642. auf der Internationalen Ausstellung in Wien im Jahre* 1873. *Osnabrück, Druck von J. G. Kisling,* 1873. 4to. Pp. 21. Plates.

The iron-ore beds Hügel I and Hügel II lie on the so-called Hügel, which is a mountain-ridge (one of the spurs of the Teutoburger forest) one and a half miles southwest from the city of Osnabrück. Brown and spathic iron-ores are chiefly obtained from them.

The coal-fields of Glückauf, Dörenberg, and Hilterberg lie in the forest clay-formation of the Osning Mountains, or the Burger Mountains, one and a half to two miles southeast of the city of Osnabrück.

It was the intention of the company to connect all their mines of coal and iron by a railroad running east and west, and then to establish at some suitable point extensive smelting-works, which should be independent of the precarious production of charcoal, and be supplied with coke. The location of these works was especially dependent upon a sufficient supply of running water, which was found in the valley of the Düte. The space for the location of the works was purchased from the government of Hanover.

The building of the works was rapidly carried forward, and in 1858 a coke-furnace was in operation. The transportation of the materials from the iron-ore fields at Hügel, and the coal-fields at Oesede and Borgloh, was done at that time by horse-power on roads constructed by the company.

The great amount of water in the Düte Valley, and the insufficiency of the machinery for its control, made the working of the coal-mines peculiarly difficult and expensive. Coal could be obtained cheaper from Dortmund, and in 1866 the working of the coal-mines of the Düte was provisionally stopped. The same combination of circumstances worked against the other coal-mines, so that after due deliberation the plan of building a railroad between the works and the coal-mines was abandoned, and the construction of a railroad between the works and the mines at Hügel and the Westphalian collieries was taken up with vigor, and in 1870 railroad communication was established with the great thoroughfare of the Cöln-Mindener Railroad.

The construction of the Hamm-Osnabrück Railroad, which is now progressing, will connect the coal-mines of the company directly with all other points, and will enable the company to work them to advantage.

The company has now the sole management of the railroad between Oesede and Hasbergen, and also that from Domprobst and Sundern to Rothenberg, and uses upon these railroads five locomotives and hundreds of freight-cars, besides passenger-cars; and they use the same not only for their own business, but do a steadily-growing general carrying-business.

The working of the little charcoal-furnace and rolling-mill at Beckerode has been suspended and superseded by coke-burning furnaces. The price of charcoal is constantly rising, while the quality of coke is rapidly improving, and therefore the company is able to produce a better quality of pig-iron at a much less cost than formerly.

The products of the Georgs-Marien Works have been principally sold to the steel, puddling, and rolling works of Westphalia for the manufacture of articles of the best quality. The iron competes favorably with the better kinds of pig-iron from Seigerland.

The rolling-mill and machine-works at Beckerode were too small and their sales too insignificant to justify their continuance. These works were therefore incorporated with the Georgs-Marien Works, which were then approaching completion; and the Beckerode shops were used for the construction of steam-boilers, mostly for home use, and in repairing machinery, using a small water-power as motor, while some of their workmen with their families lived in the house of the company at Beckerode or in the neighboring villages.

Although the Georgs-Marien Works have not yet reached their full development, either in their means or their production, in consequence of the imperfection of communication, yet the size and technical arrangements, the quality and quantity of their productions, and, not the least consideration, the number of workmen employed and the excellent accommodations for their welfare and happiness, give the works a right to claim a conspicuous place among their competitors.

The company owns, besides the already-mentioned railroads and equipments, 6 finished blast-furnaces, of which 5 are in blast, each having 3 hot blasts, each one of which has a heating-surface of 140 square meters, the apparatus being of a peculiar construction, made with hanging pipes. There are 14 crushing-machines and 5 horizontal blast-engines.

There are, besides these, various other stationary engines for different purposes, with 54 boilers of different construction, having together 3,700 square meters of heating-surface and 2,500 horse-power. The requisite coke is produced by 300 coke-furnaces, and the gas thus obtained is used as fuel for the boilers. A machine-shop and foundery are employed as an auxiliary to the works and the mines, for the manufacture of the tubes, ore-breakers, machines, &c., that are needed. The machine-shop has an engine and about 40 working machines, and all the apparatus necessary for the construction and repairing of engines and machines. Its annual production is estimated to be worth 130,000 thalers. The foundery has a blast-cylinder, 2 Irish cupola-furnaces capable of melting from 3,500 to 5,000 kilograms per hour, derricks, and all the accessory apparatus, and is capable of producing two million kilograms of castings per annum.

ıst-furnaces produced in 1872 53,118,100 kilograms of pig-ed at 1,882,000 thaler; while in 1867 the production was but) kilograms, valued at 920,000 thaler.

ld be noted that of this production, in 1872, 70 per cent. was pig, and 30 per cent. was a good quality for puddling, while, 8 per cent. was Bessemer pig, and 72 per cent. was good pud-.

ns of a peculiar contrivance connected with the blast-furnaces ɪr part of the slag from them is granulated, and thus it is capa-ng used for a variety of purposes, for example, as a packing ilroad-sleepers, in the manufacture of mortar, good bricks, &c. contrivance, the invention of the director, Mr. Lüvmann, is of ɪe. The front hearth of the coking furnaces is done away with, ırnaces are tightly closed by a form made of slag and cooled ɪr.

npany is erecting gas-works, to make sufficient for 1,000 burn-ill be used in the works and the colony of laborers.

sing and transportation of the ore is done by 7 stationary nd 5 locomotives, run by 18 steam-boilers, having a heating-501 square meters, not counting 8 horse-power above and 4 er under ground, in addition to that mentioned.

antity and value of ore raised at Hügel in 1867 and in 1872

Year.	Ore, kilograms.	Value, thalers.
	160,722,000	69,964
	222,769,385	183,590

ole works of the Georgs-Marien Company employ 1 general . metallurgical director, 1 mining director, 1 director of the ʳorks, 35 men for overseers and office-service, and 1,600 work-ibuted as follows:

ıst-furnaces	450
ındery	80
ıchine-shop	140
ilroad	80
's, builders, masons	110
Hügel I	650
ers	90
	1,600

ıpany was awarded a medal at the International Exhibition ı in 1862, and in 1867 it received a silver medal at the exhibi-ıris, for the good quality of the pig-iron produced.

The prosperity of the works is shown by the dividends paid to the stockholders in the past four years, as follows: 1868–'69, 10 per cent.; 1869–'70, 10 per cent.; 1870–'71, 8 per cent.; 1871–'72, 16 per cent.

65. INSTITUTIONS AND ASSOCIATIONS FOR THE PHYSICAL AND MENTAL WELFARE OF THE WORKMEN AT GEORGS-MARIEN-HÜTTE.—The Georgs-Marien Joint-Stock Company differs very materially from most manufacturing companies in that it not only aims to give the shareholders the largest dividends possible, but besides its industrial purposes it seeks to promote the welfare of the working classes, by forming a community of them, and establishing and supporting for them churches, schools, clubs, associations, and other beneficial institutions. Deeming this the surest way of accomplishing its purposes, the company has made this work one of its first and chief efforts.

The company was obliged to create a new industry in a part of the country where the prospects for the future were good enough to justify considerable preparations and the attempt to benefit the poor laboring classes of the surrounding villages.

This was a great undertaking, for at the time of the founding of the works they were at the distance of a half an hour's ride from the larger country roads, and could only be reached by primitive lanes and by-ways, as was also the case with the small villages. Therefore roads had to be constructed to the newly-acquired coal-fields and iron-mines, while all the old roads had to be improved.

The inhabitants of the district were for the most part farmers, and for the few such as had spare time there were always chances enough for employment at the neighboring coal-fields. This had its advantages for them, since the laborers at the works would be obliged to devote all their time to it, while at the coal-mines the mining being done by shifts, working eight hours each, they had sufficient time to work their fields also. Under the existing circumstances most of the inhabitants of the district could not take steady employment at the new works, and even those who might have done so could only be prevailed upon by the offer of higher wages, and even then they were very slow to come and begin work for the "strangers." It was, therefore, an unavoidable necessity to engage laborers from remote parts of the country, and for whom in this very thinly-settled district habitations and boarding-facilities could not be found.

66. *Houses.*—Thus the company was forced at the outset, and before any technical work could be begun, to provide houses for their workmen, on a plan which of course could not satisfy all demands for comfortable living, but which would permit of the speediest completion and give shelter to as many as possible. These houses were built with a frame-work as general lodging-houses, but so that they might afterward be converted into dwellings by the erection of partitions. Nineteen of these houses were so built, and are known as "lodging-houses."

Afterward, as the number of steady and settled employés increased, and there was more opportunity for deliberation and forethought in building, more regard could be given to the lasting comfort of the workingmen. Houses were built upon the same plan, for but two families, and so that each family had a separate entrance, shed, and yard. The disadvantages of these houses were the same as with the lodging-houses: slight frames, low ceilings, small windows, and insufficient ventilation. Then the sheds for stabling, &c., were so closely connected with the houses that they were unhealthy and not durable.

After finishing the above-described dwellings in 1859, the company decided not to enlarge the colony on this plan, believing that the workmen could be induced to take the matter into their own hands, and secure for themselves an independent homestead, and that the company would thereby secure a set of steady, interested laborers. To this end a building-plot of thirty square rods, at a standard price, and an advance of cash to aid in the erection of the proposed building, was offered to each workman. The workman had to pay 4 per cent. interest on this sum, and, moreover, allow the company to retain and apply such a proportion of his monthly earnings that the property would be unincumbered in the course of fifteen years.

The conditions for the granting of the loan were—

1st. That the plan of the proposed house should have the approval of the architect appointed by the company.

2d. That the building of the house should be under the supervision and control of the company's architect, in order to protect the builder against fraud, and in order that the company's money should be expended for this stated purpose only.

3d. That the laborer should himself furnish a part of the necessary capital.

This last clause was never fully enforced, and this was the first cause which led to the failure of this plan.

Very soon after the adoption of this plan a number of workmen made application to obtain the offered privilege and to build their own houses. In the course of building it would often be the case that enlargements would be made, and alterations of the original plan, which would demand a greater outlay than at first contemplated. Then the furnishing of the new house would cost much more than was expected. In almost every case the capital needed from the company exceeded the original demand. It resulted that the payment of the interest and the monthly deductions from the wages were too burdensome for many of the men, and, as a natural consequence, some of the houses were sold to third parties who were not interested in the success of the company, and thereby the good intentions of the latter were more or less frustrated.

To avoid these evils, the third clause was amended so as to read that the applicant for a lot and loan should possess at least a half of the needed capital. Under this condition it was thought that the builder would at least be more considerate in the use of his means; but the result of this experiment was the total suspension of building by the workmen, and the company was again forced to erect houses for their men, although much against its inclination. After due consideration, a new and well-approved plan was adopted, and upon it sixteen new dwellings were built as an experiment, and these having given entire satisfaction, the number will be increased in the course of this year by the addition of forty-four more.

The dwellings are judiciously separated from one another, as they also are from the sheds, yards, &c. The entrances to the houses are opposite each other; the rooms are high and airy. On the first floor are a sitting-room, bed-room, and kitchen; on the upper floor either one large chamber or two small ones. The cellar is large enough to hold the winter-stores, and is entered from the kitchen. The shed has two compartments—one for a pig and one for a goat, and room above for winter-fodder. A garden of from 15 to 20 square rods is connected with each dwelling.

The walls of the houses are made of the bricks made of slag, and a space of 2½ inches is left between the walls, rendering the dwellings perfectly dry.

The best evidence of the adaptation and desirableness of these dwellings to the workmen is furnished by the fact that it is looked upon as a reward and a special privilege to obtain one from the company.

The officers of the company, who originally had to live either in lodging-houses or other public places, are now also better provided for. Special buildings have been erected for them. These houses contain on the first floor five rooms and two chambers, and on the upper floor six more rooms. In the basement are the kitchen, pantry, and cellar room. In the rear are sheds similar to those of the laborers, with a garden-plot of about thirty square rods, for the cultivation of vegetables. The company owns now six houses for officers, and one so-called director's house.

Differing a little from the above-described family double dwellings are the houses for the foremen and lower officers of the works. They contain two sitting-rooms, two chambers, and basement. There are now four of these houses built, and four more in the course of erection, which will be finished this year. The possession by the company of so much fertile land enables them to lease to their workmen who desire it a plot of ground for farming, and this has proved to be a great advantage to them. It is a fact worthy of note that in this way eighty acres of rough land have been cleared and made suitable for cultivation, or converted into building-lots. The land is leased at a fixed price, and the different lots distributed by ballot among the workmen.

As has been already mentioned, the works are too distant from other communities to receive from them any of the benefits of social life. It was therefore necessary to organize an independent community, and to provide means for the solemnization of marriage, baptism, and death-

The now existing community was organized in 1860 under the name of "Georgs-Marien-Hütte."

It is evident that a united community can only exist as such when properly provided with all the requisite arrangements and necessary institutions for the bodily, mental, and moral welfare of its members, such as churches, schools, hospitals, and other associations.

67. *Schools at Georgs-Marien-Hütte.*—In January, 1857, the first evangelical private school was opened with 22 children, and at Easter, in 1862, the same was re-opened as a public school with two classes and 180 children. For this purpose an evangelical school society was formed, in which the inhabitants of the surrounding villages were received, whose children had, till that time, received their education in the existing Roman Catholic schools and their religious institutions in the city of Osnabrück, some five miles distant. There are, at present, some 280 children in the community schools, divided into four classes, under four good teachers. Another school, situated near the iron-mines at Rothenberg, has been established by the company.

The school-house building contains four large school-rooms, one confirmatory, three dwellings for married teachers, and one dwelling for an unmarried one, which can, when needed, be easily converted into another large school-room for a fifth class by taking down the partition. The southern part of the building was erected in 1864, and consisted of two large school-rooms, which, when the large double folding-doors were opened, were converted into one, and used for prayer-meetings. In 1868 the third class-room, and in 1869 the fourth class-room, were added.

The rapid growth of the school soon made the room too small, and provision had to be made for the increase of pupils by obtaining rooms in private houses, and it was only possible in 1872 to finish the northern part of the building and unite all classes under a single roof. For the accommodation of the Catholic members of the community, represented by about 60 children, the company established a temporary school in 1871. This house contains a large school-room, which is also used for divine worship, and also apartments for the teacher.

The directors of the company are the patrons of the evangelical school, and this gives them the privilege of nominating three teachers, the other being chosen by the state.

68. *Churches.*—As already stated, the rooms of the evangelical school-house, as well as of the Catholic, were constructed with the intention of using them provisionally for divine service. Although the need of a minister of the gospel was keenly felt by the members of the community, since the nearest place of worship was about five miles distant, it was not until 1867 that an evangelical, and until 1872 that a Roman, priest could be engaged, and the building of churches is now taken in hand by the respective congregations.

69. *Industrial schools.*—Near the elementary school there is a high or

advanced school for the older boys and the younger workmen. Instruction is given by the regular teachers, and by the engineers of the company, on every Monday, Tuesday, and Thursday evening; also, on Sunday mornings before church-time. Instruction is given in the following branches: German and English languages, technical and ornamental drawing, arithmetic, writing, physics, and cosmogony. The younger workmen during their apprenticeship are obliged to attend this school, which numbers, at present, about 30 pupils.

A girls' industrial school has also been established, where, under the guidance of a female teacher and some of the able housewives of the officials, the girls are instructed in knitting, sewing, and all other necessary handiwork.

Similar schools have been established also at the colony Rothenberg for young miners and girls, and they are well patronized.

70. *Libraries.*—Close by the schools stand the public libraries. They were founded in 1862, and contain now about 800 volumes, some of which are very valuable. The first and second teachers of the evangelical schools act as librarians. The books are in great demand by the workmen, especially during the long winter evenings.

71. *Court of justice.*—We cannot close this account of the institutions of the community without mentioning the peculiar court of justice which is one of the greatest blessings in the place.

The court of justice, or the peace society, strives for an adjustment of all controversies, without the intervention of the courts and the processes of the law. Members of this society are—

1st. All the employés of the company.

2d. All others who dwell on the company's grounds, and who have pledged themselves by signing the constitution and by-laws of the society.

For the settlement of all differences between the members, nine justices of the peace are chosen from among the members of the society, to serve for the term of one year. The meeting of this court is not held at definite, stated times, but whenever required, and the time of meeting is made known by public proclamation.

The members of the society are bound, in all differences between themselves, to call on this court before entering suit in any other court of law, or before denouncing one another. The parties must appear personally, and all counselors, except members of the family, are excluded.

This court of public peace was founded in 1865, and had in the beginning its hands full of minor cases of every kind and description, but the fact that its decisions were impartial and plain, and that the guilty parties had to submit generally to a severe rebuke in the presence of a great number of their friends and comrades, caused it to be feared even more than the courts of the state.

72. *The workingmen's association.*—This society is based upon the mutual-benefit plan. It secures to its members—

edical aid and care, free of expense in case of sickness.

2d. Compensation for wages lost during sickness, at the rate of one-half the regular wages, at the maximum of 12½ silbergroschen per day.

3d. A life-long pension to invalid members of from 20 to 50 per cent. of their ordinary wages, and even the whole amount of wages in exceptional cases; 25 thaler per month is the highest.

4th. One-third of the pension of a deceased member to his widow.

5th. Support and education for the children of deceased or invalid members until confirmation, (generally at the age of 14.) In exceptional cases support is given even till they have reached the age of 20 years.

6th. Assistance at burials; sometimes payment of the whole expense

The funds of the society are divided into three classes—1st. Sickness-fund; 2d. Pension-fund; and, 3d. Capital-fund.

Every workman has to contribute to the first class. They can contribute to the second class under certain conditions. All those who contribute to the first fund only are designated as "unsettled" workmen, while those who contribute to both funds are classified as "settled" workmen.

In 1872 the association numbered 1,535 members; "settled" members, 412; invalids, 2; widows, 13; children to be supported, 46.

There were spent in 1872:

	Thaler.
In cases of sickness	11,115
Pensions	770
Exceptional support	112
Burial expenses	92
Society expenses and sundries	443
	12,572
Income	20,217
Surplus	7,645

The cash capital of the association, exclusive of furniture, amounted to 39,063 thaler at the end of the year 1872.

73. *Hospital.*—For the care and treatment of the sick, a well-furnished hospital is provided. It is under the care of an excellent resident physician and nurses, and has a drug-store attached. The hospital was at first located in one of the lodging-houses, but now is in an independent building erected for the purpose by the company, and placed at the disposal of the "Workingmen's Association," free of charge.

For all technical establishments of this magnitude a hospital is indispensable, and especially is it important here; for the workmen are scattered over a large area, so that it would be very difficult, if not impossible, for the physician to pay the necessary attention to his patients in case of accident or severe sickness. In the year 1872 there were 3,345 cases of sickness, making an aggregate of 17,396 days of sickness, to which the physician would never have been able to attend were it not for the hospital.

The hospital steward is the assistant to the physician, and he provides for the inmates at certain fixed rates of compensation. There are two nurses. Charges are made to the workmen according to their earnings, the company paying at the least one-half of all that paid by the workmen.

The administration of the affairs of the Workingmen's Association is under the control of—

1st. A board, consisting of four members, two of whom are chosen by the workmen, and the other two by the superintendent of the works.

2d. A certain number (at present four) of the older regular or settled workmen.

It may be regarded as strange that so small an amount has been paid from the relief-fund of the association for the aid of its members; but, besides this fund, there are several other funds from which, under the able administration of the board, large sums are given for the welfare and benefit of the workmen.

The principal of these funds is the "workingmen's deposit-fund," which was established by a donation of 4,000 thaler in 1866, and donations have been made most liberally by the stockholders, and were 2,827 thaler in amount in 1867; 6,502 in 1868; 6,775 in 1869; 5,830 in 1870; 10,979 in 1871; 6,823 in 1872. The accounts of the board which controls these funds are examined by a supervising committee appointed by the stockholders.

The other five funds are mostly for special purposes; one, for instance, for the education of the sons of workmen who prove able and worthy; one to give Christmas presents to poor children: one for extra support of orphans. All these funds are under the controlling supervision of the directors of the works.

Besides those organizations which, like the workingmen's association, are supported by fixed dues from the workmen who belong to them, and by donations from other interested parties, there are other very beneficial organizations which have been established by the administration of the works. One of these is the—

74. *Store-union.*—This is established for the purpose of enabling its members to obtain the necessaries of life of good quality and at reasonable prices, and thereby to enable them to lessen their daily expenses, and effect a saving. To this end contracts were made with different trading-houses and store-keepers, binding them to sell good articles at fixed prices, and at a certain percentage on the cost. The association has also opened stores itself, such as grocery, hardware, shoe, crockery-stores, &c. A bakery was established in 1872, and a butcher's stand is being started.

Every workman who will comply with the rules and regulations can become a member. All the goods bought at the stores of the association or of the traders under its control are paid for on delivery with tokens, which are afterward exchanged at the treasury of the company for cash, and entered on the account of the buyer. The profits made by the stores in trade are divided among the members according to the amount of goods entered upon their pass-books. When this dividend is due they can draw the sum to their credit above three thaler at the treasury, or it can remain there bearing 5 per cent. interest, but the amount must not exceed 300 thaler, as this is the limit of capital of one individual in the store-union, allowed by the constitution.

This union is managed by a board of seven directors, four at least of whom are chosen from among the workingmen. As the store-buildings belong at present to the company, it supervises the affairs of the union, but the control will pass into the hands of the association as soon as the reserve-funds have accumulated to make a capital sufficiently large to warrant the independent maintenance of the association.

The following statement shows the amount of business done by the union: Capital deposited at the end of 1872, 15,549 thalers. Sales in this year, 17,768 thalers. Clear profits, 1,906 thalers, which, being divided among the members, after deducting the three thaler for the reserve fund, gave to each man a profit of 3½ silbergroschen to every thaler paid out in tokens.

75. *Lodging-houses.*—As beneficial to the bodily welfare of the workmen, the lodging-house is noticeable. It has been often necessary to engage large numbers of temporary workmen for the creation of extensive improvements, and at such times the want of places for lodging was strongly felt. The erection of barracks helped somewhat, but it was soon decided to furnish for this purpose permanent substantial buildings. The first buildings for this purpose were erected in 1870, one at the colony near Rothenberg iron-mines, and the other at the Georgs-Marien Works. The first-mentioned will soon be replaced by a larger one, but the latter has proved sufficient. Small rooms are provided for the accommodation of the young men, where they may occupy their leisure hours in study or literary pursuits without disturbance.

76. *Club-house.*—Quite recently it was thought possible to do something for the social needs of the workmen by building a club-house. This building is for the accommodation of the different societies and clubs; also for the meetings of the board of directors and other bodies. The building will also contain some apartments where the young, unmarried officers of the company can lodge. The smaller hall will accommodate the singing and orchestral societies, where their rehearsals can take place. The billiard and reading rooms are free to members of any society. A small hall is reserved for the meetings of different societies for culture or education, and is closed against all but members during the time of their meetings. About the building are grounds under cultivation for a park, free to all visitors. A walk of about fifteen minutes through this park leads to the shooting-gallery. A bowling-alley is near by the club-house, and is free to all visitors, save when any society is holding a sociable.

77. *The turn hall.*—This hall is nearly completed. It has a hall 13 meters long and 7 meters wide, used as a gymnasium. It has two rooms for the storage of turn apparatus, and a room for a fire-engine, hose, &c. The hall and the surrounding grounds are for the benefit of the scholars of the public schools and the Turners' Society.

The progress in the development of social life and habits has been very rapid. Already, in 1861, the first orchestral society was started by teachers, officers, and workmen. The society grew rapidly, and was well supported, though at one time it nearly succumbed. Rehearsals take place once a week, and every six or eight weeks a concert is given which is free to all members, and to their families and friends. The entertainment consists of orchestral music, solos, and singing. The directors of the company have recently engaged a musical director or leader, whose duties are to give instruction to the different musical societies free of charge. Encouraged by this, a brass band has been organized, which will eventually be the band of the colony. Especially worthy of note is the "*Liedertafel der Georgs-Marien-Hütte*," a singing society which has, not only by its numbers, but by its very beneficial influence upon the morality of the community, a just claim to superiority. This society was founded in 1862, and has among its members almost the whole corps of officers and the majority of the members of the colony. One evening in the week is devoted to rehearsals, and every six or eight weeks a social gathering, enlivened by music, song, declamation, &c., is held. The society owns a large collection of written music, and a grand piano. A branch of this society formed exclusively of workmen devote their leisure hours to the cultivation of dramatic and oratorical talent, and by their successful representations they have materially assisted in the entertainments given by the other societies.

A rifle-club was established at the same time. It gathered about forty members, whopractice weekly, and once in each year they have a prize-shooting; and this custom is becoming very popular.

It was the opinion of the better-educated classes among the different societies that there was a lack of literary and scientific culture, and that something should be done for this object. Accordingly, a new society was formed in 1870, under the name "*Vereinigung*," (union,) with the understanding that all the members of the other societies could also join this without subjecting themselves to much expense. This "union" soon received such material aid from the directors of the works that they could offer free membership to all members of the other societies, and only outsiders are obliged to pay for admission.

In their weekly meetings, the political and social questions of the day, matters of interest to the works or colony, are discussed. A selection of periodicals is furnished for the free use of the members. It is proposed to connect with the union an improvement school for the older workmen, and to erect a building for the purpose, and also a savings-bank.

The union arranges for three or four so-called musical evenings in the course of the winter, in which the different musical societies participate, and in exceptional cases outside musicians of distinction.

The "*Turnverein*" has about forty members, mostly young workmen, who meet once or twice a week. By building a new hall for this society, it is thought that the additional facilities thus afforded will increase the number of members of this most useful society.

Among the societies of the officers of the works, there is a choir or singing-club.

Upon the establishment of the different societies, the board of directors granted certain amounts either as gifts or as temporary loans. Now the board appropriates a certain sum annually, granted unconditionally for the benefit of the societies, reserving for themselves only the right of placing a veto upon the appropriation of any money in cases where there is doubt of good intention in the appropriation.

This fund is controlled by the entire board of directors, which is composed of the directors of all the different societies, by which the requirements and wants of every society are duly considered and the money divided accordingly.

78. The following official statements are made regarding the hospital, the school, and dwelling-houses.

Hospital.—The hospital is arranged for 32 beds placed in four large halls, and four single rooms with one bed each. In addition, there is an isolated house with two rooms and a morgue. The ceilings of the hospital are 13 feet high throughout; the basement, built of freestone, with an arched brick ceiling, contains the kitchen-rooms, furnaces for heating, pantries, and cellar-rooms. Besides these, there are rooms for contagious diseases, and a vapor-bath. From the first floor upward, the walls of the hospital are constructed of porous brick made of slag, with air-chambers 2½ inches wide.

The slag-bricks are made of the granulated slags from the blast-furnaces, mixed with caustic lime, and the hardening of the bricks depends upon the presence of soluble silica in the slag, which, combining with the lime, gives the bricks great firmness. These slag-bricks have proved very useful at this settlement as building-material, and deserve the attention of the public in general, as being the best material for the construction of hospitals and sanitary buildings on account of their porosity. Though as yet the examination of the physical qualities of these bricks has not been made, there is no doubt but that they have a great advantage over ordinary building-stones on account of their porosity, but they must not be mistaken for the glassy slag-bricks which are produced at other furnaces.

The location of this hospital is excellent. It is free upon all sides to the sun and air; built upon dry ground, southwest in direction from the works, and thus protected from the smoke by the predominating western and southwestern winds. Near by is a small grove of beechwoods and a small lake, through which a clear mountain-stream runs very rapidly.

The halls of the hospital are airy and light. There are no dark, close rooms. It is provided with pure water for washing and bathing from a high reservoir, into which the water is pumped by steam. The drinking-water is drawn from a well.

The principal corridor is 80 feet long, 7 feet wide, and 13 feet high, and has five windows. This hall opens into five rooms, containing in all twenty-two beds. Apartments of the same dimensions are upon the second floor. The hospital has, in addition, rooms for the physician, steward, and nurses.

The system of ventilation is that proposed by the architect, Scharrath. The principle is not to drive a large volume of heated air into the room through one or two openings, as is usual, but to distribute the heated air over the whole extent inside the walls, and admit it through small crevices in the walls, which at the same time have openings for the escape of the same quantity of foul air. The foul air is conducted away through a pipe, which is kept hot by the furnace or kitchen fires, and in summer by a special stove placed in the basement. It is the intention of the directors to increase the efficiency of this chimney by the use of steam-power, by directing a current of steam into the pipe in the summer-season. Extending lengthwise under the ceilings of the sick-room are square wooden boxes, which, after going through the whole length of the sick-room, enter the chimney. There are slits from 1 to 1½ inches wide along the box, which can be opened or shut. The advantages in this mode of ventilation are seen in the uniform distribution of heated air over a large area, thus avoiding all draughts, even when the apparatus is in its fullest activity. The heating-apparatus is in the basement, and consists of five stoves for heating the lower floor and two for heating the upper. The stoves are so constructed as to have a very large heating-surface. Thus the iron never becomes red-hot, the air is always pure and kept free from the disagreeable and unhealthy odors arising from the burning of particles of dust and other organic matters. The air in the three sick-rooms, where almost every bed is occupied, is always found to be odorless, sufficiently moist, uniform in its temperature, and entirely free from draughts, no draughts being observable either at the slits for the admission of heated air or for the exit of the foul. In room No. 1—which had eight beds and seven patients with fractured bones, very severe burns, and one who had both his legs amputated at the thighs—the healthful state of the patients and the condition of their wounds demonstrated that their treatment had been good, and that their favorable condition was in a great measure due to the good state of the atmosphere produced by the grand system of heating and ventilating of Dr. Scharrath.

School-houses.—The school-houses have in general been before described. Only a few additional remarks will be made. The two rooms for the rst and second classes are divided by folding doors, which are opened n Sundays to allow of divine worship. An organ with twelve stops as been presented by one of the former directors of the works. The uilding is built partly of sandstone and partly of slag-bricks. It is eated with stoves in the school-rooms, and the ventilation is produced y a stand-pipe, as in the hospital, but the ventilating-boxes, which in e hospital extend along under the ceiling, are here arranged around e walls at the height of the foot-boards, and thus they immediately rry away the cloud of dust raised by the many moving feet of the ildren. There are also large ventilators to serve to bring about a peedy ventilation at the intermissions. The corridors are used as play-oms in rainy weather, while in fair weather the open space protected gainst cold winds by the structure of the building serves for the pur-ose.

The Catholic school, which is used at the same time as a church, is, ough temporary, very suitable for the purpose, and includes a dwell-g for the vicar and the teacher. The seats are benches with cross-acks; the desks have movable tops, but these are to be replaced by ools and good stationary desks. At the visit to the school-rooms, hich took place directly after the dismission of the pupils, the air was und perfectly clear and free from dust, and at a temperature of 15° R., hich shows the ventilation and heating to be perfect. On a visit to ne of the older class-rooms, the air, though not found to be perfectly dorless, was yet not disagreeable, though 70 children had occupied he room without intermission for two hours.

Lodging and boarding house.—This is established with the view of ffording the unmarried workmen the means of dwelling in healthy ocalities, and receiving good and wholesome food at a moderate price. The building is constructed on the same plan as the hospital, and of the same materials, has a very high basement for the culinary department. The cooking, for about 300 boarders, is done by steam. There are rooms for about 150 lodgers. The house contains two dining-rooms, each with 600 square feet of floor, and 24 feet high. They are heated by steam-pipes in the floor, and are ventilated like the hospital and school-house. The sleeping-rooms are in the two wings of the main building. In the rooms are iron bedsteads, one placed on top of the other, two by two, with mattresses and pillows stuffed with sea-weed; they are provided with linen sheets, and one woolen blanket in summer and two in winter. Between the beds are wardrobes, one for each lodger, and numbered to correspond with the numbers upon the bedsteads. They are 5 feet high, and are fitted with locks. The common wash-room contains 20 china wash-basins, and connected with this are the water-closets, which are closed during the day-time. In the eastern wing are smaller rooms, for from one to six lodgers each, who, of course, pay more according to accommodation. There are lodgings for from 40 to 50 men in this wing, while the western wing accommodates from 90 to 100 men.

The discipline of the house is in the hands of the steward, who is responsible for the observance of certain fixed rules and regulations established by the board of directors, who also at certain times inspect the victuals. The steward pays a yearly rent, for the use of the house and furniture, of 112 thaler. Board and lodging is paid for on the following scale of prices: Coffee and milk, 6 pfennig; dinner, with a quarter of a pound of meat or bacon, for a whole portion, 3 groschen; for a half-portion, 1½ groschen; supper, without meat, 2 groschen. A boarder can procure boiling water for coffee or tea at any time free of charge, and every one procures his own bread and butter. Connected with this department, but in detached buildings, are a laundry, store-house, and bath-rooms with warm water, and for the use of which the steward collects a small fee. Near the steam-boiler is a disinfection-apparatus, into which steam can be admitted to free clothing, beds, &c., from vermin. All these rooms are well ventilated, and are always found unexceptionably clean and in perfect order.

The preceding statements show with what foresight and interest the managers of the Georgs-Marien Works care for the mental and physical welfare of their employés, and the success which they have achieved. Their action is worthy of all praise and imitation.

BOCHUM MINING AND STEEL WORKS.

79. The following list comprises the objects sent by this celebrated establishment, the *Bochumer Verein für Bergbau und Gusstahl-Fabrication, Bochum in Westfalen*:

(1.) Cast-steel propeller-screw in one piece, weighing 9,000 kilograms, about 9 tons. It is the first of its kind, and has not been forged in any part.

(2.) A cannon for a fort, of cast steel, with a bore of 21 centimeters, and about 10,000 kilograms in weight. The carriage upon which it is placed is from the manufactory of Gruson, in Buckbau, near Magdeburg.

(3.) A fort-cannon, of cast steel, of 15 centimeters bore, weighing 3,000 kilograms.

(4.) Two field-pieces, of cast steel, one 6-pounder and a 4-pounder.

(5.) A steam-cylinder for a hammer of 300 centners falling-weight, with the valve-box and base-plate all in one piece, made of crucible steel, weighing 7,000 kilograms. Near by it the piston and piston-rod, made of forged steel.

(6.) Press-cylinders of cast steel, the largest weighing 3,000 kilograms.

(7.) Cog-wheels of cast steel.

(8.) Steel pump-rod, 32 meters long and 165 milimeters in diameter, for a pump-rod, forged out of a block of cast steel. Weight, 5,500 kilograms.

(9.) A bent cast-steel cylinder for an elevator, 6,000 kilograms in eight.

(10.) A cast-steel bell of 1.83 meters diameter, weighing 2,850 kilo-ams.

(11.) A group, consisting of the different wheels for a locomotive, nder, and cars, part with cast-steel disk wheels, part wrought-iron oke-wheels. Near by the last is the inner part of a wheel made of st steel, three more made of wrought iron, and one of cast iron.

(12.) Different wheel-rims, bands, links, &c., of crucible and Bessemer eel, the greatest wheel-rim having an inner diameter of 3 meters.

(13.) *Herzstücke* of crucible steel of various construction.

(14.) A collection of springs, of various construction, made of crucible eel.

(15.) A collection of broken rails and wheel-rims, to show fracture, the mples taken at different stages of the manufacture, and the products ade from different iron and iron-ore.

80. *The cast-steel works.*—The Bochum Company has been in exist-ce for thirty years. For the first eighteen years it had but small pacity of production, and from that period to the present it has veloped its great importance. The company's works and its mines ver an area of 140 hectares. The number of superintendents and inor officers employed is 250, and of workmen, nearly 6,000. The pro-uction of cast steel at the present time is about 11,000,000 pounds onthly. This product is worth nearly $700,000. In 1872 the pro-uction was 96,000,000 pounds, worth $6,000,000, gold value.

The raw material for the manufacture of cast steel is mainly obtained om the workings of the company, and the sources will be briefly oticed.

81. *The coal-mines.*—These mines, called the "Maria Anna" and Steinbank," are situated at a distance of a half-mile from the steel-orks. They are connected by railroad with the works, and at present are furnishing a part of the fuel required for the works from a single shaft. Two new shafts are being dug, and they will furnish 25,000 bushels daily to the steel-works and blast-furnaces next year. The mining-property embraces seven square fields, and possesses an uncommon richness of coal-beds. The coal is all of the best quality.

82. *The iron-mines*, in the Siegen and Nassau districts, are numerous and of great size, and furnish an important part of the ore used in the blast-furnaces of the company. Of particular value are the spathic ores mined near Kirchen. It is a superior ore for the manufacture of spiegel and Bessemer iron.

83. *Coke blast-furnaces.*—Two of ordinary size are in operation near Mühlheim, while two more of larger size are being built at Bochum, and two more are going to be built next year, and two more in 1875.

84. *The coke-furnaces* in Mülheim furnish coke for both of the blast-furnaces. Near the steel-works in Bochum are a large number of

coke-furnaces, part in operation, and a part in process of manufacture. Both the establishments at Bochum and at Mülheim economize the gas that is produced.

85. *The steel-works* at Bochum manufacture crucible and Bessemer steel. Thirty-six steam-hammers, from the smallest to the largest size, are used in forging the steel.

The Bessemer plant runs 7 converters, principally producing material for rails and blooms to be forged into tires and axles. The Bessemer steel and crucible steel for the manufacture of tires is made into blooms of sufficient size to make from ten to twelve tires, and then is cut up into pieces of proper weight, forged, punched, and rolled out, without being reheated in a heating-furnace.

One of the special operations in the works is the casting of steel in molds, after the invention of the technical director of the works, Mr. Jacob Mayer. The importance of the invention was acknowledged by the bestowal of the great gold medal of honor at Paris in 1855. Although the process was not patented in the country, it remained for ten years the exclusive property of the company and of those works in France and England which had obtained the patent-right. The great screw for a steamship, which was made for one of the ocean-steamers, having a diameter of 5⅓ meters, (17½ English feet,) as well as other heavy pieces, such as the press-cylinder and the cast-steel bell, with their sharply-defined coats of arms and inscriptions, show the significant progress of the Bochum cast-steel works.

The cannons exhibited show the favorable condition of this department. The first one, with a bore of 21 centimeters, was tested with five hundred shots to prove its durability, and fifty shots to prove its strength, by the imperial commission. The testimony of the commission and inspection of the piece both show that the piece has undergone no noticeable change in diameter or shape of the bore. The range of the piece with ordinary charge is 8,000 meters, which is more than a German mile.

The other pieces were also subjected to the most trying proofs, and show no change, either in the bore or the straightness of the piece. With these pieces are seen some missiles, some of which are new and some of which have been fired. The crucible steel for cannons is made according to a rule peculiar to the Bochum works, and patented by them. The steel is not brittle, and is characterized by its toughness and homogeneous nature.

86. Another specialty of these works is the manufacture of cast-steel bells. We have not space to detail all the advantages and virtues of cast-steel bells. The manufacture of these bells dates from the year 1851. As early as 1855, at the Paris Exposition, the bells of the company attracted general attention. The surprise of the inspectors at this new cast-steel product, indeed, the doubt as to the possibility of working steel in this way, was so great that they desired an inquiry to be made, to ascertain whether these bells were really steel, as was represented, or whether they were made of cast iron.

result of this inquiry was the bestowal of the great gold medal
jury of the exposition, upon the following grounds:

e exhibited bells are characterized by perfection of performance,
very clear, unmixed tone, which is as clear as that of the best or-
bronze bells."

consequence, the jury came to the conclusion—

at the Bochum Company, by its method of melting and pouring
ave not only superseded bronze as the material for bells, but
given a new direction to the manufacture of large forged and
pieces for machinery."

far-seeing decision of the French jury has received a brilliant
ation by this year's exhibition. It was not only a great advance
retical knowledge, with but little development by practice, which
ned the surprise of the jury, for that which they characterize as
ction of performance" is not only "*progress*" but a "*great pro-*
ealized."

e bells are cheap, costing only half as much as bronze bells; they
vy, and, since 1855, their manufacture has very greatly and rap-
creased.

he year 1858, a test proved "that it is impossible with human
to crack one of these steel bells with heavy sledge-hammers."
practical use which has been made of them since the beginning
r manufacture, they seem to far outlast the bronze bells.

ng the first seventeen years, the number of church-bells that
ade was about 1,000, and about 1,500 of smaller kinds. In the
ur years about 600 church-bells and 1,500 smaller bells have been
f cast steel.

Bochum bells are widely distributed over the whole of Europe,
the distribution is somewhat limited by the fact that they are
ctured both in England and in France under patent-rights
d by the Bochum works. Besides the great number that are sus-
l in Europe, six have been sent to Asia, ten to Africa, forty-five
th America, and five to South America. Most of those to whom
ave been sent have written, showing their perfect satisfaction.

following is a price-list of the works:

ll weighing 100 kilograms, 20 silbergroschen per kilogram.

ll weighing from 100 to 150 kilograms, 18 silbergroschen per
am.

ell weighing from 150 to 15,000 kilograms, 16 silbergroschen
ogram.

e good service that their bells have rendered, the company has
nt guarantee that their cast-steel bells will not crack, and they
ver offer to buy back any bells that shall crack in the future, at
e price of the new ware. However, up to the present time,
cking of one of the church-bells is unknown. The smaller kinds
s are used for locomotives, for example) are the only ones which
ver been known to break.

87. *Extent of the Bochum works.*—For transportation within the cast-steel works, 6 locomotives, 100 cars, and 60 horses are used. Steam-engines, together of 7,500 horse-power, with 150 steam-boilers and a very large hydraulic power, are employed for driving the works.

The steel-works have in and near Bochum, 16 puddling-furnaces, 8 heating-furnaces, 92 annealing and warming furnaces, 27 cupola and reverberatory furnaces, 121 steel-melting furnaces, 135 forging and welding fires, 44 furnaces for heating air, 24 crucible, tube, and brick burning-furnaces.

There are 2 blast-furnaces now building, and 4 projected, which will soon be completed. Each of these six is capable of producing from 120,000 to 130,000 pounds of pig-iron daily.

In addition, there are 80 cranes, with and without steam-power; 4 crucible and brick presses, 5 clay-mixing machines, 21 grindstones, and 300 working machines of various kinds.

Also, 36 steam-hammers, the heaviest 600 centners falling-weight; and one of 1,200 centners is being set up.

The monthly production of railroad-stock is as follows: 1,000 combinations (2 wheels and 1 axle) of car-wheels; 40 full sets of wheels for a locomotive and tender, with the appurtenances; 2,000 car and 350 locomotive axles; 6,000 springs for locomotives and cars; 10,000 spiral springs for locomotives and cars; 16,000 to 18,000 rails; 200 to 300 *Herzstücke;* 150 to 200 *Gehobelte Weichenzungen.*

88. *Aid for the workmen.*—An institution, in the form of a joint-stock company, has been established which has for its object the building of cheaper and better dwellings for the workmen and employés of the company, the obtaining and the production of the necessaries of life, the care of the old workmen and the support of their families. The capital of the institution amounts to 1,500,000 thalers, of which 300,000 were received from the Bochum Company, 200,000 from the workmen and the former employés of the company, and 1,000,000 thalers is a loan. After deducting the large interest, (at 2 per cent.,) the remaining sum is devoted to the above-designated objects.

GLEIWITZ FURNACE, UPPER SILESIA.

89. The *Hochofen zu Gleiwitz in Oberschlesin* Company makes a most instructive exhibition of the progressive changes in the form, size, and production of their furnaces at different periods since 1799. There are four large drawings of equal scale, 1 to 10, giving sections of the furnaces in 1799, 1829, 1854, and 1872, showing in a vivid and impressive manner the gradually-increasing size and production. The data taken from these drawings are herewith tabulated.

Table showing dimensions and production of Gleiwitz blast-furnaces at four different periods.

Dimensions, number of tuyeres, and production.	Year.			
	1799.	1829.	1854.	1872.
Dimensions of furnace:				
Height .... meters..	11. 18	13. 14	15. 04	13. 04
Diameter at top .... meters..	0. 96	1. 36	1. 88	3. 92
Diameter at boshes .... meters..	3. 45	3. 14	4. 79	5. 34
Diameter at or above tuyeres .... meters..	0. 94	0. 63	0. 94	2. 56
Capacity .... cubic meters..	....	48. 14	117. 58	220. 70
Tuyeres .... number..	2	2	3	8
Weekly production .... kilograms..	13, 700	25, 000	56, 250	250, 000

CHAPTER III.

FRANCE.

EXHIBITION BY THE SCHNEIDERS, CREUZOT; ATTRACTIVE INSTALLATION; THE ORES AND METALS USED; MANGAN-IRON; EXTENT OF THE WORKS; CLASSIFICATION OF IRON AND STEEL; TABLE OF THE PHYSICAL PROPERTIES OF SEVEN TYPES OF IRON MADE AT CREUZOT; COMMERCIAL STEEL AND ITS PHYSICAL PROPERTIES, AS CLAIMED AT CREUZOT; QUALITY OF RAILS; PRICES ACCORDING TO QUALITY AND HARDNESS; LARGE CASTINGS FOR LINING MINING-SHAFTS; REVOLLIER BIETRIX & CO. AND OTHER EXHIBITORS; ALGERIAN ORES.

90. The exhibitors of the iron and steel products of France did not enjoy the advantages of a separate building for the reception of objects pertaining to the mining and metallurgical groups, and consequently their exhibits were distributed in the Machinery Hall and parts of the main building, and were not so readily found as those of Germany and Austria.

The iron and steel production of France is shown by the annexed tabular statement from the years 1859 to 1874, inclusive:*

Years.	Cast iron.	Wrought iron.	Steel.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1859	758, 682	531, 769	16, 922	1, 307, 373
1860	797, 932	503, 229	21, 244	1, 321, 605
1861	829, 481	591, 772	26, 169	1, 447, 422
1862	928, 574	648, 395	30, 490	1, 507, 459
1863	933, 907	707, 785	25, 372	1, 667, 064
1864	1, 034, 161	750, 881	28, 189	1, 813, 231
1865	989, 972	676, 775	31, 816	1, 698, 563
1866	992, 710	759, 142	28, 286	1, 780, 138
1867	931, 906	704, 160	36, 855	1, 672, 921
1868	934, 868	718, 272	66, 320	1, 719, 460
1869	1, 018, 899	801, 201	97, 284	1, 917, 384
1870	923, 842	617, 834	83, 788	1, 625, 464
1871	859, 641	635, 876	79, 811	1, 575, 328
1872	1, 217, 838	884, 203	130, 088	2, 232, 129
1873	1, 366, 715	889, 891	155, 568	2, 412, 174
1874	1, 423, 307	862, 254	217, 072	2, 502, 633

* From the *Bulletin du Comité des Forges de France*, cited by David Forbes.

Pig-iron for refining, for foundery purposes and for the manufac-steel, classified according to quality and appliances. Furnace-the same. Some mangan-iron of high percentage, claimed to con-per cent. of manganese, was shown. This is made by adding nese ore to a bath of molten iron in the presence of charcoal in a s furnace.

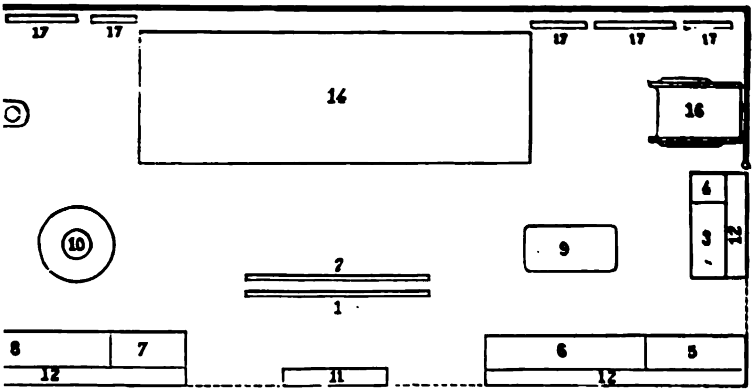

FIG. 58.—Plan of Creuzot exhibition—general arrangement.

ıresque view of Creuzot.
netrical plan of Creuzot.
ı show-case.
erals.
iron.
ıught iron.
) Steel.
liances of the iron.
pliances of the steel.
(11.) Fractures of iron and steel.
(12.) Rolled profiles of pieces of iron and steel.
(13.) Engine of 20 horse-power.
(14.) Locomotive, Midi Railway.
(15.) Wheels, axles, and tires.
(1) Cylinder of marine engine.
(17.) Drawings of bridges.

Wrought iron classified by numbers of quality, from 1 to 7. bars showing the respective physical properties of each qual-

d 8.) *Steel* classified by numbers of hardness, from 1 to 11, and ks of quality, A, B, C.

Specimens showing the quality of the iron, classified according ıumbers, worked up either cold or hot, and different appliances.

Specimens showing the quality of the steel, classified accord-he numbers, worked up either cold or hot, and different appli-

Fractures of rails and other pieces of iron and steel, showing ture of the metal.

Profiles (cross-sections polished) representing the rails and nt iron made by the Creuzot Iron-Works.

establishment manufactures engines and locomotives, and they , upon the space marked in the plan 13, an engine for workshops, with vertical cylinders on frames; high and low pressure, with condensation; 20 nominal horse-power; patent governor.

In the center space, marked 14, a highly-finished freight-engine for steep gradients, for the Midi Railway Company; eight wheels coupled; outside cylinders. Weight of engine empty, 47 tons 8 hundred-weight. This locomotive is one of twenty made to order by the works in 1872.

(15.) Upon this space *railway-wheels and axles* are shown in a highly-finished state. Both axles and tires are of Creuzot steel. Axles and tires of the same pattern and finish are shown folded up and bent in opposite directions without exhibiting a flaw.

(16.) Upon space 16, opposite the steam-engine, they exhibit a *steam-engine cylinder*, rough from the foundery, as cast for the paddle-engines, with high and low pressure, of 350 horse-power, of the steamer Petrel, of the French navy. This piece weighs seven tons. The diameter of the high-pressure cylinder is 3 feet 1$\frac{15}{16}$ inches, and of the low-pressure, 5 feet 1$\frac{5}{8}$ inches; stroke of pistons, 3 feet 3$\frac{1}{2}$ inches.

(17.) In the spaces marked 17 there are several *models, plans, and drawings* of public works, bridges, viaducts, aqueducts, &c., among them a drawing of the bridge of Friburg, on the railway from Lausanne to Friburg, 1859, of which the iron-work weighs 3,000 tons; the swing-bridge of Brest, 1860, weight of iron-work 1,170 tons; the bridge on El Cinca, Spain, 1866, weight of iron-work 247 tons.

Drawing of the bridge on the Chiffa, Algiers, 1868; weight of iron-work 419 tons.

Drawing of the bridge on the Danube, at Stadlau, near Vienna, constructed at Creuzot in 1869 for the I. R. P. Company of State Railways, scale $\frac{1}{400}$. Distance between abutments, 1,264 feet 8 inches; number of columns, 4; distance between centers of columns, 263 feet 2 inches; weight of iron-work, 2,140 tons.

There is also a diagram showing the manner in which the bridge has been put into its place by hauling.

Drawing of the bridge on the Danube, at Vienna, constructed at Creuzot in 1873 for the administration of the public-works department, scale $\frac{1}{400}$. Distance between abutments, 1,088 feet; number of columns, 3; distance between centers of columns, 275 feet 6 inches; weight of iron-work, 2,400 tons.

94. PRODUCTION.—The exact statistics of the works, as regards extent and production for 1873–'74, are as follows:

V
Ling

Statistics of Le Creuzot, 1873-'74.

Statistical elements.	Creuzot.	Appendages.	Total.
HE WORKS consist of—			
face of the works and of the industr'al appendages..	435	336	771 acres.
face of the buildings	51	17	68 acres.
gth of railways, broad gauge	35	14	49 miles.
narrow gauge	18	62	80 miles.
mber of workmen	9,800	5,700	15,500 workmen.
mber of steam-engines	234	74	308 engines.
se-power of the same	15,700	3,300	19,000 horse-power.
PRODUCTION.			
ight of coals	190,000	525,000	715,000 tons.
ight of pig-iron	180,000	....	180,000 tons.
ight of wrought iron	90,000	....	90,000 tons.
ight of steel	60,000	....	60,000 tons.
ue of locomotive-engines, (100 a year)	280,000	....	280,000 pounds.
lue of other machinery and bridges	240,000	100,000	340,000 pounds.

ote.—The extensions of the works at present in progress, and which are to be completed in 1873-'74 taken into account in these statistics.

95. Awards in 1867.—At the Paris Exposition in 1867 a grand prize as given for the raw and finished products of mineral industry, (Group , class 40,) and another grand prize for mining-tools and processes of rking the mines, (Group VI, class 47.) A gold medal for railway-marial; a gold medal for civil engineering; a gold medal for materials naval architecture and saving of life; a gold medal for methods of ching children and apparatus for the same, and also a bronze medal M. Nolet, as co-operator, for apparatus for the instruction of adults.

96. Classification of iron and steel, Creuzot.—The classifican before mentioned is based upon the needs of the consumer, the envor being made to meet in a uniform and reliable way the demand eady existing for iron and steel of certain qualities. In the notes d descriptions which follow upon this subject free use has been made the valuable notes, in French, furnished by the firm.

When Messrs. Schneider & Co. decided to greatly extend their tallurgical works, they necessarily became solicitous that the outlets their products should also be extended. To attain this end, the est means was to seek to satisfy all the wants of the consumer in reect of quality as well as of form, or, in brief, to put into the market equivalents of the principal varieties of iron in common demand. eir first step was to procure a certain number of bars of the same ecimen of the brands best known in France, England, Belgium, and all producing countries. These bars were submitted to mechanical ts when cold and when hot. From the data obtained from thousands experiments in this way, the coefficients of strength were deduced, presenting the relative value of each variety. It was found that the nost infinite varieties of quality produced by metallurgy could be ouped in seven chief divisions, and that these seven groups or types uld satisfy all the needs of trade and the consumer. It then reined to find the means of realizing in practice the manufacture in the ge way of these seven types of iron with uniformity and regularity.

Chemical analysis of both the irons and the ores was resorted to, and the mixture of ores was based upon the analysis. The result, after long efforts, has been that the Creuzot Works produce seven distinct types or qualities of iron, denominated by the numbers 1 to 7, which can be relied upon, and which have been well received in commerce. The physical properties of each of these qualities of iron are shown in the succeeding table.

IRON.

Numerical table of the physical properties of the seven types of iron made at Creusot.[*]

Pulling-stress.		1.		2.		3.		4.	
Iron in bars. Bars turned to 200mm² of section, and to 100mm long.[†]	*Sheet-iron.* Specimens cut 1,000mm wide, 2,500mm long, and 10mm to 12mm thick.	Bars.	Sheets.	Bars.	Sheets.	Bars.	Sheets.	Bars.	Sheets.
Permanent elongation at the moment of breaking		10	......	15	6.5	18	10	21.5	14.4
Charge of breaking per square millimeter of primitive section.		41	......	37.8	33.2	38	33.7	38.5	34.4
Charge of breaking per square millimeter of the section as broken.		51.3	......	55.5	35.6	60.3	37.6	67	41.5
"Striction," (or relation of the primitive section to the broken section.)		0.800	......	0.680	0.940	0.630	0.805	0.575	0.847
Coefficient of quality, hot ‡		40		50		60		70	

	5.		6.		7.	
	Bars.	Sheets.	Bars.	Sheets.	Bars.	Sheets.
Permanent elongation at the moment of breaking	25	18.2	29	22	34	26.5
Charge of breaking per square millimeter of primitive section.	38.6	34.8	38.75	35.6	39.2	36.7
Charge of breaking per square millimeter of the section as broken.	73.6	43	83.5	48	112	55
"Striction," (or relation of the primitive section to the broken section.)	0.524	0.808	0.462	0.740	0.350	0.663
Coefficient of quality, hot ‡	80		90		100	

[*] The figures given in this table are the result of numerous trials; nevertheless they are only comparative and approximate.

[†] The bars used were all carefully and exactly brought to the same dimensions, and were tested in the same apparatus and manner, and by the same persons.

[‡] By an empirical process, justified by experience, the comparative value hot is expressed by coefficients of which the maximum, 100, corresponds to the best charcoal-irons.

97. *Commercial steel.*—A similar method of investigation was adopted in respect of the various grades of commercial steel, and resulted in grouping these varieties in three grand divisions, designated respectively by the letters A, B, and C.

The first division, A, includes the great bulk of production of steel; the greater portion of Bessemer and of Martin steel, and some crucible steel made in England, Belgium, and in France. This grade of steel is used generally in rails and other objects of general manufacture.

The third division, C, includes steel of exceptional purity, which, according to numerous analyses, is only to be found in the best products of the crucible from charcoal-iron of the best Dannemora brand.

The second division, B, comprehends the steels of intermediate quality between A and C.

The Schneiders have undertaken to realize in their manufacture in the large way each of these three standard types of quality to a degree at least equal or superior to the mean of each, and they have adopted the three marks A, B, and C to designate three grades of steel which they claim to be able to produce with uniformity. They observe, however, that the physical properties of the same metal are so greatly modified by its degree of hardness that it is necessary to take this hardness into consideration.

The elongation of bars of steel under strain varies more with the degrees of hardness than from any small differences of chemical composition. The elongation is an essential quality, which for the same bar varies greatly with the different degrees of hardness. The classification adopted by the Creusot Works is based upon the hardness rather than the composition. Other metallurgists have taken the degree of carburation as the basis of classification.

This basis of elongation being taken for the classification, it became necessary to fix the extremes. For the hardest they have selected a steel which is susceptible of an elongation of 12 to 14 per cent., or an average of 13 per cent., and for the softest, which permits of 34 to 36 per cent., or a mean of 35 per cent., of elongation. They are able to produce at will such steel, and to maintain the production, as regards this quality of hardness and elongation, within the limits of variation of 1 per cent., more or less. They have also been able to subdivide each of these three groups A, B, and C into grades of hardness differing by 2 per cent. of elongation, commencing at 13 per cent. as the basis, only as the extreme limit of elongation recedes, as the purity of the steel increases, they have 9 numbers for quality A, 10 for quality B, and 11 numbers for quality C.

The classification so adopted, with the numbers for each division, and their comparative resistance to pulling-strain, are shown upon the annexed table. The bars used in these experiments were all carefully turned to a diameter giving 200 square millimeters of section, and were 100 millimeters long. They were hardened in oil.

STEEL.

Numerical table of the physical properties of standard steels made at Creusot, by quality of metal and degree of hardness.

Pulling-strain turned bars, 200mm² of section and 100mm in length.	Mark of quality.	Degrees of hardness.							
		1		2		3		4	
		Not tempered.	Tempered.	Not tempered.	Tempered.	Not tempered.	Tempered.	Not tempered.	Tempered.
Permanent elongation at the moment of breaking.	A	13	2	15	4.8	17	7.2	19	9.4
	B	13	3.8	15	5.7	17	7.8	19	10.2
	C	13	5	15	6.6	17	8.6	19	10.8
Breaking-charge per square millimeter of primitive section.	A	76.2	117	73.6	110.5	70.3	105.6	66.8	96.8
	B	77.7	119.3	74.9	115	71.8	108	68.2	99
	C	79	123	76.2	118.3	73.2	112	69.8	104.8
Breaking-charge per square millimeter of the section as broken.	A	95.2	119	98.5	120	101	122	103.2	123.5
	B	98	125.2	101	128	104.2	130.8	107	133.5
	C	100.2	132.2	104	136.5	108	141	113	146.3
"Striction," (or relation of the broken section to the primitive section.)	A	0.800	0.980	0.749	0.930	0.697	0.865	0.646	0.790
	B	0.793	0.950	0.740	0.900	0.687	0.827	0.636	0.765
	C	0.788	0.930	0.732	0.867	0.678	0.794	0.617	0.730
Charge corresponding to the limit of elasticity.	A	39	72	37.8	68.3	36.4	65.8	34.9	60.6
	B	41.1	78.5	40	75.5	38.8	71	37.3	65.4
	C	43.2	85	42.2	82	41	78	39.8	72.5
Coefficient of quality, hot..	A	120		120		120		120	
	B	125		125		125		125	
	C	130		130		130		130	

Pulling-strain turned bars, 200mm² of section and 100mm in length.	Mark of quality.	Degrees of hardness.							
		5		6		7		8	
		Not tempered.	Tempered.	Not tempered.	Tempered.	Not tempered.	Tempered.	Not tempered.	Tempered.
Permanent elongation at the moment of breaking.	A	21	11.1	23	13.2	25	14.6	27	18
	B	21	12.6	23	14.8	25	17	27	19.5
	C	21	13.3	23	16	25	18.2	27	20.6
Breaking-charge per square millimeter of primitive section.	A	62.8	88.6	58	78.7	53.2	68.6	49.2	61.2
	B	64.4	91	59.7	82	55	73.8	50.5	65.8
	C	65.9	99	61.5	89.8	56.8	81.2	52.2	72.6
Breaking-charge per square millimeter of the section as broken.	A	105.6	125	106.8	126.5	108	124.1	110	129.7
	B	110.8	136.2	113	138.7	115.2	142	119	145.1
	C	115.5	151.2	119.6	156	123.2	160.5	127.5	165.4
"Striction," (or relation of the broken section to the primitive section.)	A	0.595	0.710	0.544	0.625	0.493	0.535	0.441	0.473
	B	0.582	0.670	0.529	0.590	0.477	0.520	0.425	0.453
	C	0.570	0.655	0.514	0.575	0.460	0.508	0.409	0.449
Charge corresponding to the limit of elasticity.	A	33.2	56.2	31	50.3	28.8	43.8	26.6	37.8
	B	35.8	62.1	33.8	55	31.8	49.8	29.6	44.7
	C	38.3	68.8	36.5	62.2	34.8	56.9	32.7	51.2
Coefficient of quality, hot...	A	120		120		120		115	
	B	125		125		125		120	
	C	130		130		130		125	

umerical table of the physical properties of standard steels, &c.—Continued.

rain turned bars, of section and n length.	Mark of quality.	Degrees of hardness. 9 Not tempered.	9 Tempered.	10 Not tempered.	10 Tempered.	11 Not tempered.	11 Tempered.
t elongation at ent of breaking.	A	29	21	....	....	....	....
	B	29	22	32	24.2	....	....
	C	29	23.4	32	27.6	35	33
charge per square er of primitive	A	45	56.2	....	....	....	....
	B	46.7	58.8	41.3	51.2	....	....
	C	48.2	63.8	43.5	53.2	39.3	46
charge per square er of the section n.	A	114	131.3	....	....	....	....
	B	123	147.5	127	152	....	....
	C	132.6	170	140	175.2	146.6	180.5
," (or relation of en section to the e section.)	A	0.395	0.428	....	....	....	....
	B	0.379	0.398	0.325	0.337	....	....
	C	0.363	0.375	0.310	0.305	0.268	0.255
rresponding to of elasticity.	A	22.5	33.6	....	....	....	....
	B	27.5	40	23.6	33	....	....
	C	30.7	45.3	27.8	37.2	24.4	32.8
of quality, hot..	A	110		....		....	
	B	115		110		....	
	C	120		115		110	

otwithstanding the great number of the experiments and the th which they were made, the figures are not given as absolutely thematically accurate, but as approximations and comparative ry of course somewhat according to the operator, the instruments, n, and the preparation of the specimen, and, further, according intrinsic qualities of the metal. The bars, however, were all as nearly as could be, in the same manner and turned to the same ons, and the experiments were confided to the same person, and l conducted alike.

esilience.—The results published by the Creuzot Works at comprise, it will be noted, only elongation and "striction," (the between the area of the fracture and the original section.) xperiments upon pressure and blows have been made in great s; but owing to the extreme difficulty of breaking the bars, es. among the higher numbers, it has not yet been possible to tabu- these results. The conclusion, however, is that in a general way, l of equal quality, the resistance to shocks has a constant relation oftness of the metal; therefore, for most uses, and particularly hinery, preference should be given to soft steel.

The experiments have not only been laborious but delicate,* and cupied years of time. The tabular statements represent only part of a series which the Schneiders contemplate publishing,

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scertaining the charge corresponding to the limit of elasticity, the experi- sed the cathetometer of Froment, with two lenses.

and these were presented in advance simply on account of the exhibition. Chemical investigations of all the steels and the materials used are also in progress.

Each pouring of steel at the works is submitted to physical tests, and these are combined from time to time with chemical analyses, and these investigations are conducted in such a manner that the production of steel is under the closest surveillance and control, and can always be kept within the prescribed limits as to quality.

101. *Deductions.*—The examination of the tabulated results here presented suggests some general conclusions. In regard to the hardness, it is seen that it is less affected by the tempering in proportion to the softness of the metal. At the extreme of the grouping and for the purest metal the hardening does not greatly affect the elongation, but increases the other properties. This metal is a kind of homogeneous iron, or melted iron, the chemical composition of which is the same as that of the best charcoal-irons. We pass by insensible degrees, in a chemical point of view, from the hardest steel to the softest iron, with this great difference always, that the iron is produced by the agglutination of elements more or less thoroughly welded, while steel is the result of fusion, which assures its homogeneity, and gives it special qualities.

102. The second observation is that, under the generic name of *steel*, some thirty different qualities are recognized and differentiated by their physical properties and by their chemical constitution, giving distinct metals, so to speak. There is no resemblance between quality A, No. 1, and quality C, No. 11. The name is the same, but the substances are different. This apparently very simple matter is of great importance in practice. A failure in an application of steel proves nothing against it, but rather against the choice made of the quality, which may not have had any adaptation to the purpose in view.

It is impossible to define "good steel" in an absolute manner. Tool-steel is not adapted to the construction of machines. It is the same with iron. A quality which is excellent for sheets, gives miserable rails, and reciprocally. In the varieties of iron and of steel made at Creuzot, each purpose or application of these substances may find its appropriate quality. The product best adapted to the end in view may be selected with confidence. The tables which are published are intended as a guide to the consumer, who will select the number of iron or steel which has the physical qualities best suited to his purpose. The following general statement is also to be considered:

Rails are always made of quality A, of which the numbers of hardness range from 1 to 5, according to the preferences of railway companies, the conditions of track, climate, traffic, &c. French railways generally use hard rails; American, soft rails; and Russian railways prefer rails of intermediate quality. For tires, parts of machines, axles, sheets, &c., the higher numbers of quality A are most used, but it o use quality B. The quality C is used for special purposes, certain plates, axles, ordnance, and other exceptional objects equire the greatest possible strength of metal.

For commercial purposes, use is made of the annexed tables of d of hardness.

Increase of price according to quality, hardness, &c.

Marks.	Increase of cost per 100 kilograms.	
	By quality.	By hardness numbers.
....	0 francs....	From 1 to 7, inclusive, 0 franc.
....	15 francs....	From 8 to 11, inclusive, 2 francs.
....	30 francs....	(Per number.)

COMMERCIAL HARDNESS TABLE, CREUZOT.

ate elongation obtained on bars 200 *square millimeters of section and* 100 *millimeters long.*

Marks.	Classification numbers.										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
....	13	15	17	19	21	23	25	27	29	....	....
....	13	15	17	19	21	23	25	27	29	32	....
....	13	15	17	19	21	23	25	27	29	32	35

IRON LINING FOR MINING-SHAFTS.

The company *des Hauts-Fourneaux de Marquise* exhibit large cast for circular shafts sunk on the Chaudron and Kind systems. ve made these linings of the following diameters:

	Exterior diameter.	Interior diameter.
....	$2^m.40$	$2^m.16$
71	3 .45	3 .21
73	3 .89	3 .65

have supplied linings to the following localities:

	Height of column.
lle Company, France..........	$87^m.00$
lle Company, France..........	75 .00
u, United States, Louisiana..........	135 .00
in, France	75 .00
....	49 .50
in..........	70 .50

maximum thickness of these linings is 45 millimeters. They y will sustain a pressure of nearly 13 atmospheres; the maxi- 18 atmospheres.

VARIOUS EXHIBITS, FRANCE.

The establishment of Revollier Bietrix et Cie., St. Etienne, ex- st-steel tires, and a number of other firms of the Loire united in a collective exhibition of considerable interest. The *Société Anonyme des Acieries et Forges* of Firminy, Loire, under the direction of F. F. Verdie, manufacture railway material, rails, axles, tires, cast steel, &c. They have a capital of 3,000,000 francs, and a production in 1872–'73 valued at 10,000,000 francs. They produce 21,600 tons of pig-iron annually.

The *Société des Acieries à Ermont* exhibit a variety of articles of cast steel in illustration of the Lesset process, (3 Boulevard Hausman, Paris,) consisting of wheels, plowshares, ornaments, cog-wheels, tools, gratings, railway-frogs, axes, &c. Some grape-leaf ornaments are very sharp and delicate, with a fine surface. The samples are malleable, and bear doubling up when heated. The same firm send a large drawing, in colors, of a furnace for heating crucibles by Ponsard's process, illustrated also by folio plates published by the *Société Métallurgique pour l'exploitation du procédés Ponsard.*

106. ALGERIAN ORES.—There are some masses of specular iron-ore from the departments of Oran and of Constantine, also hematites and siderite and peroxide of manganese. These are shown by the mining department of Algeria. The ores of Mokta-el-Hadid appear in the exhibition made by Creuzot and by other establishments. The production of iron-ore in Algeria was nearly 400,000 tons in 1872. Mokta-el-Hadid supplied over 350,000 tons. According to Forbes,[*] the company owning this mine raised and sold 372,849 tons, and divided 7½ per cent. on the capital stock. The profit for 1872 reached the sum of £119,797.

The number of men employed in the iron-mines of Algeria at the commencement of the year 1874 was 2,655. The exportation of iron-ores during the years 1872 and 1873 was as follows, in metrical tons:[†]

To—	In 1873.	In 1872.
France	267,331	251,598
Netherlands	64,265	40,900
Belgium	13,670	4,290
Germany	....	1,503
England	62,098	61,157
Spain	25	....
United States	11,504	....
	418,893	359,497

The portion shipped to the Netherlands was for transmission to Germany.

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[*] Report on the Progress of the Iron and Steel Industries in Foreign Countries, 1873.

[†] From reports of David Forbes 1875.

CHAPTER IV

BELGIUM.

ACE AND MILLS AT LIÉGE; SCLESSIN COMPANY; ROLLED TIRES, OUGRÉE
; JOHN COCKERILL COMPANY; DESCRIPTION OF THE COCKERILL WORKS,
KE-FURNACES, ETC.; THE PRODUCTS OF THE WORKS; MINING-MACHINERY.

e exhibitors of iron and steel in Group I, from Belgium, are but
iere is a notable absence of any printed information concerning
nd steel industry, or indeed any of the industries classed in
roup, while under agriculture, the second group, the catalogue
l with statistical descriptions.
f exhibitors are—
nonyme des Charbonnages, Haut-Fourneaux et Laminoirs de
, at Liége, and at Seraing, near Liége. This company sends
f coal and coke, and of pig-iron, at 150 francs the 1,000 kilo-
d sheet-iron from 450 francs.
ntity and value, estimated, of the production of the Belgian
in the years 1871, 1872, and 1873 is given as follows:*

BELGIAN IRON-WORKS.

	1871.	1872.	1873.
:			
tivity	48	52	54
ns	609, 230	655, 565	607, 373
	£4, 794, 552	£2, 616, 823	£2, 809, 929
orks	174	168	176
tons	70, 427	79, 863	81, 393
	£538, 561	£841, 685	£1, 000, 201
orks	58	57	53
tons	467, 216	502, 577	480, 374
	£3, 369, 787	£4, 979, 254	£5, 570, 002
:			
orks	62	63	54
tons	33, 145	28, 393	23, 058
	£474, 119	£427, 962	£428, 025
acted, tons	697, 272	749, 781	503, 565
	£253, 107	£295, 617	£240, 891
teel-works	2	3	3
tons	8, 900	15, 284	19, 050
	£126, 800	£231, 240	£311, 200

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* *L'Annuaire statistique de la Belgique*, cited by David Forbes.

The official returns published by the ministry of finance show the following as the importations and exportations of iron-ores and cast and wrought iron of every description:

IRON-ORES.

	Importations, in metrical tons.			Exportations, in metrical tons.		
	1874.	1873.	1872.	1874.	1873.	1872.
Germany	542,996	487,468	586,038	1,268	35,299	34,162
Netherlands	13,522	9,467	13,656	14,536	56,555	41,187
England	4,744	380	624	3	192	....
France	180,401	227,247	180,360	92,355	122,993	103,647
Spain	19,763	10,013	7,932	....	....	....
Italy	800	191	....	....	....	....
Algeria	2,549	4,016	1,966	....	....	....
Sweden and Norway	1	755	14	....	....	....
Other countries	2	....	....	40	....	....
Total	764,778	739,536	790,590	108,202	215,029	178,996

CAST AND WROUGHT IRON.

	Importations, in metrical tons.			Exportations, in metrical tons.		
	1874.	1873.	1872.	1874.	1873.	1872.
Pig and scrap	161,485	145,211	137,008	11,137	27,207	49,696
Castings	1,175	1,265	981	5,096	5,265	5,003
Bar-iron	2,546	2,508	3,090	2,937	2,211	2,611
Rails	14,431	9,677	7,512	92,226	72,942	81,486
Plates and sheets	422	1,279	562	26,090	18,910	94,988
Other wrought iron	3,265	4,710	3,823	103,807	87,597	101,654
Anchors and chains	94	111	78	5	17	31
Nails	577	477	341	11,066	9,765	13,346
Other manufactured iron	3,221	3,588	3,536	16,555	12,802	15,389
Total	187,216	168,826	156,931	268,919	236,716	292,918

108. BEAMS, GIRDERS, ETC.—*Société Anonyme des Hauts-Fourneaux, Mines et Charbonnages de Sclessin*, near Liége. This company exhibits a variety of beams, girders, round iron and steel, angle-iron and segment-iron for forming hollow posts, and iron and steel rails, for all of which they claim superiority of form and manufacture. Their list of prices (November, 1872) is as follows:

	Francs
Girders, 300^{mm}, price per % kilograms	46.00
250, 237, 235	44.00
135 by 150 and 130 by 150	40.50
Segmental iron for beams and posts	38.00
Iron rails	32.00
Steel rails	46.00

109. ROLLED TIRES.—The Ougrée Company of Seraing, (*Société de la Fabrique de fer d'Ougrée à Seraing, près Liége,*) of whi

the general director, makes a fine exhibition of rolled weldless tires for railway-carriages, tenders, and locomotives; also car-wheels and axles, all either of fine-grained iron, puddled steel, or Bessemer steel. The tires are beautifully arranged one above another, held together by bands and bolts, so that they form a high pyramid, with the smallest tires at at the top. One of the tires shown is 10 feet or more in diameter. The rings of steel from which the tires are rolled are also shown, together with numerous illustrative sections of axles and tires displaying the quality of the material.

This establishment was founded in 1836. It has participated in most of the great international exhibitions, and has received numerous medals.

JOHN COCKERILL COMPANY, AT SERAING.

The principal establishments of the Cockerill Company are situated at Seraing, Belgium, six miles from the town of Liége, in the valley of the Meuse, upon the carboniferous formation which runs through the territory. They occupy the estate which was used as a summer-residence by the bishop-princes of Liége until the end of the last century.

110. *Société John Cockerill.*—But by far the most important exhibition in this department from Belgium is that made by the celebrated works of John Cockerill, concerning which interesting information was freely supplied, and is as freely used.

The works comprise coal and iron mining, the reduction of the ores, the fabrication of cast and wrought iron and steel, the construction of machines and mechanical and manufacturing engines, boilers, metallic bridges and vessels.

The management is vested in a board composed of five members, assisted by a director-general.

The establishments comprise the offices for the direction, a special engineering service for the studies of construction, a library, and a laboratory for analyzing the raw materials. There are, as respects the working, eleven special divisions, managed by chief engineers.

The foundation of the Seraing establishments is due to John Cockerill, born at Haslington, Lancashire, on August 3, 1790. His father had in 1799 introduced at Liége the construction of machines for wool-spinning, and, after having acquired there a great fortune, left, in 1813, his factories to his two sons, James and John.

Coal and iron mining, the smelting of charcoal pig-iron, and wrought-iron works had been organized in the Liége territory for centuries. Besides husbandry and connected occupations, the working class of the country was mostly composed of coal-miners, smelters, blacksmiths, cutlers, nail-makers, lock and gun smiths. Materials and workmen were not wanting.

In 1817, Cockerill Brothers bought from the Netherlands government the palace of Seraing, with its appendages, and established at first works for the construction of steam-engines and machines for spinning flax, and afterward a flax-spinning mill.

John Cockerill came to reside at Seraing in 1822, and bought the grant of coal-mines upon which the works stand, and took the proper measures to introduce on the continent the smelting of cast iron with coke and the fabrication of iron according to the English process.

The working of the factory was then chiefly supported by orders from the Netherlands government. In 1824, magnificent steam-engines of 300 horse-power were constructed under John Cockerill's supervision for the men-of-war of the country, while the English navy had engines of 150 horse-power only.

In 1826, the first coke blast-furnace, the furnaces, the rollers, the hammers, the blast-engines, and the engines for the iron-factory, were used. The coal-pits were fitted up with powerful exhausting and drawing machines.

The first continental railway was decreed by the Belgian government after the revolution of 1830, and the first locomotive was constructed for that railway in 1834, by the Seraing Works, which, soon after, supplied all the engines for the beginning of the Belgian net-work of railways.

The Seraing establishment continued to increase rapidly until the demise of John Cockerill, which happened in 1840. It comprised, in 1842, at the formation of the joint-stock company—

1st. The grant of coal-mining, with three collieries furnished with all the pumping and lifting engines.

2d. Thirty-seven coke-kilns of large size.

3d. Two blast-furnaces with steam-bellows, and grants of iron-mines.

4th. A vast iron-smeltery and a copper-foundery.

5th. An iron-factory, with 35 reverberatory furnaces, 5 sets of rollers, the hammers, the divers steam-engines, the tools and apparatus to complete the fabrication.

6th. An engine and boiler factory, containing 144 forge-furnaces, 280 lathes and boring-machines, 200 planing, grooving, tapping, and perforating machines, &c.

There were 2,200 employés and workmen.

The moving power was equal to 920 horse-power.

The Seraing establishments were placed, in 1829, by John Cockerill, under the general superintendence of Gustave Pastor, his nephew, and the latter continued his services when the company was formed until 1866, at which time M. Pastor withdrew and was replaced by M. E. Sadoine, chief engineer of the government navy, now the general director.

The gradual improvements of the works, continually enlarged, have brought the productive powers of the various divisions to their present state. They now comprise—

Coal-mines.—Four collieries, with 8 shafts for raising the coal to the top, ventilation, exhaust, letting down and bringing up the workmen by Fahrkunst; 24 engines, together of 900 horse-power; 2,400 workmen Since 1867, women work no longer in the collieries of the company. Annual production of fuel, 350,000,000 kilograms.

Coke-furnaces.—Four groups comprising 143 horizontal kilns, 12 groups comprising 216 Appol kilns, 3 hammers, and 6 washers; 6 steam-engines to pull out the coke, 13 steam-engines of 168 horse-power colectively; 140 workmen. Annual production of coke, 140,000,000 kilograms.

Iron-mines.—Thirty mines in the Belgian provinces of Liége and Namur, in Luxembourg, and in Spain. Seventeen engines, equal to 306 horse-power; 800 workmen. Annual production of the mines, 150,000,000 kilograms.

Blast-furnaces.—Five blast-furnaces, with apparatus for heating the air, and tapping-sheds for ordinary casting, yielding annually 55,000,000 kilograms; 4 blast-furnaces for steel pig now building; 15 engines, colectively of 480 horse-power; 300 workmen.

Founderies.—Two iron founderies and one of copper, 2 workshops for earthen molding, steam-cranes, 1,000,000 kilograms foundery frames; 6 engines, of 90 horse-power collectively; 280 workmen. Annual production, 5,000,000 kilograms.

Iron-works.—Seventy-five reverberatory furnaces, 12 rollers, 7 hammers; 55 engines, of 1,900 horse-power collectively; 1,240 workmen; 10,000,000 kilograms in rails, girders, bar and sheet iron as annual production.

Steel-works.—Ten Bessemer converters from 5 to 7 tons, 6 of which are being mounted; 16 reverberatory furnaces, 7 hammers, 4 rollers; 46 engines, of 3,079 horse-power collectively; 560 workmen; 17,000,000 kilograms steel as annual production, before the use of the unmounted apparatus.

Forges.—Twelve reverberatory furnaces, 7 hammers, 70 forge-furnaces; 5 engines, of 288 horse-power; 200 workmen; 1,500,000 kilograms mechanical pieces as annual production.

Engine-shops.—Three hundred and sixty-eight lathes, mortisers, planers, perforators, tap-borers; 5 machines to forge bolts and screw-nuts; 2 hydraulic presses; moving-cranes, stationary steam-cranes, and others; 20 engines; 1 hammer of 264 horse-power; 1,400 workmen; 7,000,000 kilograms machines and mechanical apparatus as annual production.

Bridge and boiler building.—Fifty-five drilling, arching, cutting, planing, canting, and clinching machines; 3 hammers; 54 forge-furnaces; 11 engines, of 120 horse-power collectively; 510 workmen; 6,000,000 kilograms boilers and bridges of various kinds as annual production.

Antwerp ship-building yard.—Stock of tools appropriate for a ship-builder's yard, covered stocks, rafts and boats, shear, slides and slips for launching sea and river steamers; steam-carpentry and joinery; 2 engines of 15 horse-power; 680 workmen: 2,500,000 kilograms naval constructions as annual production.

Interior conveyances and forwarding.—Fifteen locomotive-engines, from 10 to 15 horse-power, employed on the junctions of the interior railways with the North line; 420 workmen; 60 horses, 15 of which in the collieries.

112. *Miscellaneous statistics.*—The area of the works is 200 acres, intersected with 22 kilometers railways of large section, and 12 kilometers of small; containing, besides, a basin communicating with the Meuse by a canal, and 2 wharves.

In 1872 there were 8,912 people occupied, employés and workmen, for all the works.

There were 254 steam-engines, of 7,834 horse-power in all.

The wages paid annually amount to 8,500,000 francs.

The consumption of fuel amounts to 350,000,000 kilograms.

The production of the divisions is 25,000,000 to 30,000,000 francs.

The establishment owns on the heights of Seraing, in a very healthy situation, a vast infirmary, kept by nuns; it holds eighty-five beds. A special physician is attached to it. An orphan asylum, containing at present forty-one children of both sexes, adjoins it.

The establishment possesses also a dispensary, which delivers medicines gratuitously to the persons attached to its works and their families.

In each division there is a refectory established after the best manner, for the meals of the workmen and the preservation of their food; some kitchens are added to several of these refectories, and some baths are put up at the collieries for the miners.

Lastly, a society for relief and pensions is instituted, without being compulsory, for the people of the works, and the establishment accords besides, out of its own funds, temporary relief and pensions to the workmen and employés not concerned in that society.

The Seraing works have constructed, (January 1, 1873:) 2,100 steam-engines, from 4 to 600 horse-power, for all manufacturing purposes; 900 locomotive-engines; 31,500 sets of mechanical apparatus and various pieces for manufactories, complements for factories, repairs, for mining, the reduction of ores, the fabrication of metals, buildings, sugar-works, plate-glass manufactories, paper-mills, spinning-mills, trellis and suspension bridges, iron-clad turrets, &c.

The ship-yards of Antwerp and St. Petersburg (the latter discontinued) have supplied navigation with 282 sea and river steamers, yachts, mail-steamships, steam-tugs, pilot-boats, light-ships, dredging-machines, transport-ships for travelers and merchandise, transatlantic packets, floating docks for iron-clad frigates of the first class and monitors.

The Cockerill Company has facilities and implements sufficient to supply annually 100 locomotives; 70 steam-engines, from 4 to 1,000 horse-power and above, for maritime navigation; 1,500 sets of mechanical constructions, complete works, special apparatus, repairs, &c.; 6,000 tons various bridges, turn-tables, &c.; sea and river steamers of 5,000 tons burden altogether; besides the surplus not consumed in its works of fuel, ores, cast and wrought iron, rails, and steel above mentioned.

At Liége, by the initiative of Cockerill, senior, the first factory for spinning-machines was established on the continent, and at Seraing, by John Cockerill, the first coke blast-furnace and the first puddling-fur-ace was put into operation, and afterward the first coke-kilns were rected for the making of iron after the English method.

The first steam-engine, and afterward the first locomotive-engine, on he continent were constructed at Seraing.

From 1824, besides the large steam-engines for maritime navigation, he Cockerill establishment constructed very powerful steam-engines or the drainage of the collieries of the Liége Valley, where they are still working.

The establishment has been constantly improving, and has from its oundation maintained the first rank for its various productions, as shown by its uninterrupted growth, the steady increase of its business, and its success in all the exhibitions in which it has taken part.

It exhibits at present at Vienna the following constructions and products:

113. *Packet-boat engine.*—Marine engine of 220 nominal horse-power for he mail-service of the Belgian government between Ostend and Dover.

The steamers carrying the mail between Belgium and England are remarkable for their great and regular speed, their accommodations, and, above all, they are appreciated for their nautical qualities in stormy weather. Their speed in calm weather reaches 17 knots an hour, and is not exceeded by that of any other Channel steamer. The average passage during six months, between Ostend and Dover, has been 4 hours 4 minutes.

This result is not inferior to that of the steam-packets between Holyhead and Dublin, of 2,000 tons, with engines of 750 horse-power.

This speed is owing to the perfect forms of the ships, to the relative power, to the combination and excellent make of the engines.

The latter have given at the official trials a power stated at nearly 1,600 horses.

The brilliant success obtained by the first of these ships, supplied in 1866 to the Belgian government, the Louise Marie, and the requirements of the mail-service, induced the government to cause seven of these steamers to be built without the least change of model. Six are running regularly. The engine destined for the seventh is at the exhibition.

All the principal forged pieces are Bessemer steel, coming from the steel-works of the Cockerill Company, such as the shafts, the connecting-rods, and the columns.

The ships have been built in the ship-yard of the company at Antwerp; the engines in the works at Seraing. Length at water-line, 200 English feet; breadth, extreme, 20 English feet; depth, 13 feet 3 inches; register, gross, 568 tons; draught with 40 tons of coal, 7 feet; register, net, 505 tons.

The dimensions of the engines are as follows:

Diameter of the cylinders, 58 inches; stroke of pistons, 4 ft. 6 in.; extreme diameter of the wheels, 21 feet; breadth of the paddles, 7 ft. 10 in.; pressure per square foot of the boilers, 30 pounds.

The magnificent steamer Alexandre II, built by the company for the

Volga, is provided with engines similar to those exhibited. That ship is the first "People's Line" steamer navigating the European rivers.*

114. *Blowing-machines for blast-furnaces.*—The style of vertical blowing-machine used is peculiar to the Cockerill Company, and has received the name of "Seraing system."

The first machine of that system, with high pressure, without expansion or condensing, was built in 1853. It has been working twenty years without requiring any other than ordinary repairs.

Since that epoch this style of engine has constantly been improved. The condensing and expansion in two Woolf-system cylinders has been added. The results obtained have been such that the machine exhibited is the one hundred and third of that style constructed by the Cockerill Company, besides twenty-four more now in construction in the Seraing works.

The number would be much greater had the company been able to fulfill all the orders received.

The advantages of the system come from the direct action between the impelling and resisting power, from the great length of the strokes with moderate swiftness of the pistons, from the strong expansion accomplished in two cylinders, and from the condensation.

The blowing-machines constructed by the Cockerill Company vary much in size. The machine exhibited is of the largest model hitherto built; but there are some still more powerful now in construction.

The wind-cylinder of the machine exhibited is 3 meters in diameter, and the length of the piston-stroke is 2.44.

In usual working, the machine makes 12½ revolutions per minute, and with an effective pressure to the boilers of 4 atmospheres, it gives, per minute, 250 cubic meters of wind with a pressure of 20 centimeters.

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*The following report from M. Delcourt, chief engineer of the naval department, gives an idea of the working of these engines:

"ANTWERP, *February* 6, 1873.

"SIR: You request me by your letter of the 4th instant to address you a report on the working of the oscillating engines of 220 horse-power of the mail-boats between Ostend and Dover.

"I am happy in being able to state that those engines, some of which have been working nearly six years, have highly satisfied us, and answer peculiarly well our special service.

"As you are awa. that servi requires a perfect regularity and a speed maintained in foul weather. Never having but a limited number of boats, considering the rapid increase of our intercourse with England, we have been particularly favored, insomuch that, except a few contingencies, the keeping in repair and repairing of our engines have never required longer than the time allotted for the usual stoppage of our steamers, which is never considerable. To give you an idea of it, the Leopold steamer has performed no fewer than 896 passages between Ostend and Dover, and *vice versa*, from March 4, 1869, until the 1st of January, 1873, which gives a distance gone over of about 55,000 miles of 1,355 meters.

"In short, the engines of our mail-boats, by their simplicity and their excellent mounting, have required but very few repairs, and have allowed us to perform an excellent uninterrupted service, notwithstanding the very small number of our boats considering the great quantity of passages we had to make.

"I am, sir, your obedient servant,

"G. DELCOUR,
"*Chief Engineer of the Naval Department.*

"To the DIRECTOR-GENERAL."

The Cockerill Company builds also powerful vertical blowing-engines for Bessemer-steel-works, compressing the wind at 1½ effective atmospheres.

The productions of the Seraing founderies being altogether remarkable for the beauty of the workmanship and of the molding, and the absence of defects, a rough column of blowing-machine, such as it comes out of the mold, is also exhibited, and is truly a fine piece of casting.

115. *Locomotive-engines for the railway company of Upper Italy.*—Dimensions of the engine: number of wheels, all moving, 6; diameter of wheels, 1.31 meters; space between wheels, 3.37; diameter of cylinders, 0.45 meter; stroke of pistons, 0.65. Furnaces: interior height, 1.60 meters; depth, 1.265; breadth, 1.086. Brass tubes: number, 195; length between plates, 2.25 meters; exterior diameter, 0.05 meter. Interior diameter of the boiler, 1.33 meters; weight of the empty engine, 30,674 kilograms; weight of the loaded engine, 34,376 kilograms. Extreme dimensions: length, 8.542 meters; breadth, 2.900; height, 4.260.

The locomotive-engine is exhibited as a specimen of good construction and of perfection of workmanship.

The company has supplied the railway company of High-Italy with forty-seven engines of this style, and is now constructing twenty-four for the same railways.

Small locomotive-engines for stations and service of the works.—The Cockerill Company has constructed within three years small locomotive-engines with vertical boilers for the interior traffic of its works.

The excellent results obtained, as well for the service as for economy, have been so successful that sixty-three of these engines have been supplied to manufacturers, and a dozen are in construction.

Ten engines of that style, besides more powerful ones previously constructed, are employed for the traffic in the Seraing Works.

The company constructs three types of these engines. The first can draw, horizontally, a load (engine not included) of 60 tons; the second draws, under the same conditions, 90 tons; and the third, 160 tons. The engine exhibited is of type No. II.

The dimensions are as follows: Number of wheels all coupled, 4; diameter of wheels, 0.605 meter; space between the axle-trees, 1.400 meters; diameter of pistons, 0.200; stroke of pistons, 0.250; total fire-surface, 8 square meters; contents of the water-tanks, 0.675 meters; contents of the coal-bunkers, 0.195; rough weight, when used, 7,500 kilograms; length, 2.220 meters; breadth, 2.110 meters; height on rails, 3.150 meters.

116. *Perforators for mining or rock-drills.*—From the beginning of the boring of Mount Cenis, the Cockerill Company participated in that great work.

The first air-compressed engines used at the Coscia, at Genoa, as trial, were constructed at Seraing.

The excellent results obtained, the great productive means of the company, and the active concourse that the illustrious author of the boring of the Alps, Mr. G. Sommeiller, met at Seraing, induced the Italian government to intrust the Cockerill Company with the construction of all the mechanical working-stock, without exception, necessary for the boring of the great tunnel.

The company has supplied for the boring of the Alps more than four million francs' worth in engines of all kinds; wheels, water-wheels, water-column engines, compression-machines, perforators, air and water conveyers, &c.

The construction of air-compressed engines and perforation by machinery has since become a special branch, carried to a high degree of perfection.

Fifty compressing-engines have been constructed in its works, more than five hundred perforators have been sold to manufactories, and numerous machines of that kind are now in construction. Mechanical drilling has greatly increased of late. The Cockerill Company uses it in its collieries, and it has supplied the Belgian and French collieries, &c., with many complete sets, and is continually receiving orders for machines of that kind.

Appreciating the experience acquired by the Cockerill Company, and acknowledging the superiority of the system, the St. Gothard Tunnel Company made an agreement for the supply of a part of the compressing and perforating machines it requires.

Two drilling-machines are exhibited.

The first has a certain historical interest. It is one of the machines employed by Sommeiller at Mount Cenis, where it has been for a long while in use.

The second is a simplification and modification, made from that of Mount Cenis, by MM. Dubois and François, engineers at Seraing. This perforating-machine is constructed by the Cockerill Company for mines, and has been chosen for the boring of the St. Gothard.

117. *Steel and iron forgings.*—The production of large forgings (the crank-axles for locomotives, the crank-shafts for sea and river steamboats, the locomotive and wagon wheels, &c., in short, the mechanical forgings of all sizes and shapes) has always been one of the branches for which the Seraing works have enjoyed merited reputation.

The fabrication of locomotive and wagon-wheels principally, forms a special branch of the large forges of Seraing, by a peculiar process for which the company has patents.

As specimens of its usual manufacture, the Cockerill Company exhibits a moving-wheel of 1.30 meters diameter, weighing 783 kilograms; a wheel of locomotive-engine 2.20 meters diameter at the revolving circle, weighing 731 kilograms; a locomotive-wheel, wrought-iron plate, 1 meter diameter, gross weight 520 kilograms; a box for locomotive-engine, weighing 79 kilograms; a head of locomotive-piston, weighing 75 kilograms; a support for locomotive-slide, weighing 95 kilograms.

118. *Production of the steel-works.*—The Cockerill Company has long had in its establishments of Seraing a considerable steel-work; vast buildings for its enlargement will soon be finished.

That part of the works supplies the other parts of the establishment for the construction of machines and manufactures with special productions of varied forms.

Rails, tires, machinery of every kind and size, gun-barrels, guns, and hoops for large-caliber guns are manufactured there.

As specimens of finished mechanical pieces, the Cockerill Company exhibits the piston-rods, connecting-rods, cranks, crank-shafts, levers, pivots, &c., of the marine engine which it exhibits, and also, as special productions of usual workmanship, rails, tires, springs, straight and crank axles, steel plates; a steel hoop with trunnions for cast-iron gun of large size, (an 80-pounder, diameter, 0.24 meter); a steel hoop without trunnion for the same gun. These hoops are destined for the government of the Netherlands. A field-piece;* an assortment of gun-barrels; a collection of various patterns.

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* *Summing up of the experiments made by the Belgian government with a Bessemer-steel gun of the John Cockerill Company.*—The experiments have been divided into two series; the object of the first series was to ascertain the hardness of the steel, the second series the resistance to the corrosive action of the gases and powder, and the absolute resistance of the steel, (cohesiveness, resistance to bursting.)

The gun was at first bored caliber 4, so as to be able to take off the impressions produced by the first firing.

Ten shots with 1½ kilograms powder, 1 wadding, with box for ball, weighing 3.3 kilograms.

Five shots with the same load and some *débris* of projectiles inclosed in linen bags.

After this firing, the piece was brought back to the royal gun-foundery to be examined and bored caliber 6, (95.5 millimeters.)

No apparent damage could be discovered.

Second series.—Five shots with 1 kilogram powder, 1 wadding, 1 ball; 5 shots with ½ kilograms powder, 1 wadding, 1 ball; 5 shots with 1½ kilograms powder, 2 waddings, balls; 5 shots with 1½ kilograms powder, 3 waddings, 3 balls; 5 shots with 1½ kilograms powder, 4 waddings, 4 balls; 5 shots with 1½ kilograms powder, 5 waddings, balls; 5 shots with 1½ kilograms powder, 6 waddings, 6 balls; 5 shots with 2 kilograms powder, 6 waddings, 6 balls; 10 shots with 3 kilograms powder, 5 waddings, 5 balls.

The experiments determined by the war-minister being terminated, the gun was brought back to the foundery to be examined.

No apparent injury was ascertained by this examination.

The officers of artillery composing the board asked the war-minister for his consent to continue the experiments. The firing was renewed in the following manner: 5 shots with 3 kilograms powder, 6 waddings, 6 balls; 5 shots with 3.5 kilograms powder, waddings, 6 balls; 5 shots with 3.5 kilograms powder, 7 waddings, 7 balls; 5 shots with 4 kilograms powder, 7 waddings, 7 balls; 10 shots with 4 kilograms powder, 8 waddings, 8 balls.

With the load of 4 kilograms, 8 waddings, and 8 balls, the gun was filled to the muzzle.

The gun was again brought back to the foundery and examined. It was ascertained that the bore was very nearly intact.

The board, struck by the extraordinary resistance of that gun, declared that Bessemer steel was every way proper for the fabrication of field-pieces.

119. *Models of boats and floating lock-gate.*—The works have from their beginning been engaged in constructions for river and maritime navigation.

The ship-yards of Antwerp and St. Petersburg (the latter discontinued) have supplied navigation, as previously stated, with 282 sea and river steamers, which have generally fulfilled, as to solidity, elegance of form, complete internal arrangements, means of propulsion and accommodations, all the conditions stipulated in the agreements. The two iron-clad monitors with turrets, propellers, and machine for turrets, air-exhausters, gun-carriages, centrifugal pumps and accessories supplied to Russia in 1864, had been ordered on the 18th of June, 1863. They were forwarded to be mounted to St. Petersburg at the end of October, 1863, and were delivered to the imperial Russian government completely remounted and armed, after trial, on June 13, 1864, (in less than one year.)

The company can build annually fourteen sea and river steamers of any burden.

The models exhibited belong to some of its most remarkable constructions.

The company exhibits a floating lock-gate and some models of steamers.

The floating lock-gate is intended for the canal of the Danube at Vienna. It is to prevent the pieces of ice coming from the breaking up of the main river entering the arm called the "canal," from collecting there, and thus causing the low parts of the town to be overflowed.

The lock-gate is 158½ Vienna feet in length, 30 in breadth, and 18 feet in height. The iron used for its construction weighs 300 tons of 1,000 kilograms. It has been constructed from the draughts of G. de Engerth, C. E., an aulic councilor and member of the board for the improvement of the Danube.

The statement which this board makes of its labors gives all the details concerning it.

What principally characterizes the specialty of the works, workshops and ship-building yards of the Cockerill Company is the supply of all the working stock necessary to railways; of all the implements for metallurgical works, such as blast furnaces, iron and steel factories, or for mechanical works, steam engines, stocks of tools, in short, of all steamers, dredging machines, lighters, machines necessary for the execution of a work such as that of the Suez Canal, or of engines of any kind, with or without steam, propellers, machines and working-stock for the boring of Mount Cenis tunnel. The company also send for such undertakings persons peculiarly suited for mounting, putting in working order, or [illegible] the machines which they supply.

CHAPTER V.

THE IRON AND STEEL INDUSTRY OF SWEDEN.

The completeness and extent of the display; General view of the production; The Fagersta Steel-Works; List of objects shown; Analyses of the ores used; Composition of the steel of various grades; Fagersta steel gun-barrels; Notice of Kirkaldy's experiments and memoir; Examples of pulling-stress upon plates annealed and unannealed; Bulged plates; Wikmanshytta steel; Condition of the iron-manufacture in Sweden; Professor Ackerman's memoir; The distribution of iron-ore; Sources of fuel; Transportation; English coke; Water-power; Geological association of the ores; Production of iron-ores and localities; Methods and costs of mining; Bog-ore and limonite; Pig-iron; Transportation; Bar iron and steel; Bessemer steel; Martin's steel, cement steel, etc.; Rolling-mills; Statistics of production; Chemical composition of Swedish ores.

120. The Swedish iron industry.—The Swedish contribution is characterized by the number and excellence of the specimens of ores, in large square blocks, which form a very appropriate foundation for tastefully-arranged pyramids of bar iron and steel. It is the best collection of magnetic and specular ores in the exhibition, and was made, at the cost of the Swedish Iron Association, by Professor Ackerman, author of an interesting brochure upon the production of iron in that country. Bessemer steel and Martin's steel, in ingots and bars, are also prominent objects in the collection. Here, too, is found a very complete series of samples of the celebrated Dannemora steel, and specimens illustrating each stage in the manufacture of steel from granulated pig-iron, powdered ore, and powdered coal. There is an extensive display also of spiegel iron from Schisshyttan, containing from 16 to 20 per cent. of manganese. The production of iron-ores in Sweden in the year 1871 reached 662,888 tons; of bar-iron, 187,000 tons; of Bessemer steel, 8,000 tons. The production has been steadily increasing, and will be much greater for the year 1873.

121. Fagersta Steel-Works.—This well-known establishment was well represented by the materials used and the products, as will be seen by the following list, which includes the remarkable series of test-specimens shown from the testing-works of Mr. David Kirkaldy:

Bessemer steel from the Fagersta Steel-Works, manufactured without alloy of "Spiegeleisen," or of other cast iron.—(1.) Iron-ores, not roasted; iron-ores, roasted; lime; pig-iron, with the blast-furnace slag appertaining thereto.*

(2.) Steel ingot, 18 "tum" (21 inches) square, planed; series of 8 "tum" (9⅓ inch) ingots, fractured, of various degrees of hardness, with the steel slag appertaining thereto;* series of forged blooms, fractured; plate blooms, fractured.

(3.) Pyramid: Side A, saw-blades; side B, steel for machinery, square and round, from ½ to 5 "tum" (7/12 to 5⅚ inches) in diameter; side C, rails for tramways and angle-irons; side D, steel for springs, from 1½ to 5 "tum" (1¾ to 5⅚ inches) in breadth.

(4.) For mechanical and engineering works, heavy axles, crank-shafts, other forgings for machinery.

(5.) Railway material: Axles, springs, buffers, (American patent.)

(6.) *a.* Steel for tools and implements; *b.* Mining implements, (bores and sledges;) *c.* Gun-barrels; *d.* Five gun-barrels, subjected to severe testing experiments at Carl Gustaf's Stad Gun-Manufactory, as described in the annexed statement; *e.* Gun-barrel, proved at the Husqvarna Gun-Manufactory, as described in the annexed statement; *f.* A series showing the different stages in the process of manufacturing gun-barrels; *g.* A series of fractures made on steel bars of 1 "tum" (1⅙ inches) square, of various degrees of hardness; *h.* A series of Bessemer products, taken at different periods during the blow; *i.* Plates for heliography: (a.) Polished plates; (b.) Samples of heliographed plates, together with impressions.

(7.) Steel of different forms, and of various degrees of hardness, proved, as regards its strength, at Mr. D. Kirkaldy's testing establishment, London, by experiments in tension, bending, compression, torsion, &c. A statement of the results is contained in special tables, which are distributed on application to the secretary of the Swedish exhibition.

122. *The iron-ores and limestone* employed at the charcoal-blast furnaces at Westanfors and Fagersta consist of the following component parts:

	Iron-ore from the mines of—			Limestone from Hedkärra.
	Östra Stortägten.	Granrot.	Gröndal.	
Silica	27.49	3.10	6.35	10.82
Alumina	1.30	2.05	1.15	7.15
Lime	2.16	1.20	2.65	36.61
Magnesia	1.76	1.05	3.85	6.86
Protoxide of manganese	0.81	10.40	5.50	1.35
Protoxide of iron	20.74	23.56	22.82	....
Sesquioxide of iron	46.14	52.44	50.78	....
Carbonic acid	....	6.10	5.95	37.18
Phosphoric acid	0.016	0.009	0.014	0.007
	100.416	99.909	99.064	99.977

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* For analysis, see Annex No. 1.

The average chemical composition formed by the mixture of these iron-ores with the limestone, employed as flux, is as follows:

	Per cent.	Oxygen.	Oxygen.	
Silica	11.93	6.37		
Alumina	2.50	1.16		
Lime	7.51	7.53	2.14	
Magnesia	2.76		1.10	$\frac{7.53}{4.51}=1.66$
Protoxide of manganese	5.63		1.27	
Protoxide of iron	19.76		4.51	
Sesquioxide of iron	43.89			
Carbonic acid	6.02			
Phosphoric acid	0.013			

Such a charge yields, upon smelting, from 48 to 50 per cent. of pig-iron, which is tapped direct from the blast-furnace into the Bessemer converters, and consists on the average of the following component parts:

	Per cent.
Carbon, combined	3.460
Carbon, graphitic	1.289
Silicon	0.771
Manganese	4.491
Phosphorus	0.027
Sulphur	trace.

The blast-furnace slag contains:

		Oxygen.	Oxygen.	
Silica	41.96	22.83		
Alumina	7.02	3.27		
Lime	25.04	25.65	7.16	
Magnesia	17.75		7.09	$\frac{25.65}{15.78}=1.62$
Protoxide of manganese	6.57		1.48	
Protoxide of iron	0.23		0.05	
Alkalies	not determined.		15.78	
	98.57			

As no alloy of specular iron (*Spiegeleisen*) or of ordinary cast iron is employed, the "blow" must be stopped when the proportion of carbon in the steel is reduced to the proper degree. Notwithstanding this, the steel is entirely free from red-shortness.

The following analyses show the chemical compositions of the various classes of steel employed for the purposes specified:

	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
	Per cent	Per cent	Per cent	Per cent	
(a) Steel for soft plates, railway-axles, &c	0.085	0.008	Trace.	0.025	Trace.
(b) Steel for gun-barrels, shafts, &c	0.25	0.036	0.234	0.022	Trace.
(c) Soft steel for tools—saws, &c	0.70	0.032	0.256	0.023	Trace.
(d) Hard steel for tools—chisels, turning-tools, &c	1.05	0.067	0.355	0.028	Trace.

An analysis of the slag from the converter, taken at the close of the process, shows its composition to be as follows:

Silica	46.70
Alumina	4.24
Lime	0.48
Magnesia	0.17
Protoxide of manganese	32.37
Protoxide of iron	15.63
	99.59

"I, the undersigned, hereby certify, on requisition to that effect, that barrels manufactured at the Fagersta Steel-Works have, for about the last three years, been exclusively employed for the small fire-arms constructed at the Swedish Government Gun Manufactory for the supply of the army, and that such barrels are still employed for the fire-arms now in course of construction at the said manufactory.

"Stockholm, the tenth day of April, 1873.

"C. G. BREITHOLTZ,
"*Master of the Ordnance.* ("*Fälttygmästare.*")

"Since the commencement of the year 1871, the Husqvarna Arms Manufactory has taken its requisite supply of gun-barrels from the Fagersta Steel-Works, and found the said barrels, both as regards material and make, to be of excellent quality.

"On behalf of the Husqvarna Arms Manufactory Company, Limited,
"VICTOR ANKARCRONA, *Managing Director.*"

[illegible] FAGERSTA STEEL GUN-BARRELS.—The following is the report of the proving experiments upon barrels manufactured at the Fagersta Steel-Works, made at the [illegible] Gustaf's Stad's Gun Manufactory, in the month of May, 187[illegible]

"The barrels were proved [illegible] the manufactory with gunpowder from [illegible] Gunpowder Mills of the make of 1865. The [illegible] employed weighed [illegible] drams 11 grains avoirdupois, and were [illegible]

"[illegible] bored as delivered [illegible] and discharged.

"[illegible] Fagersta Steel-Works, [illegible] 1 ball [illegible] 7 grains were [illegible]—for the ordinary [illegible] 1 scruple 3 [illegible] 1 [illegible] number of balls was increased [illegible] was that in two [illegible] escaped through the touch-hole. These barrels were reloaded and discharged with the same result.

"After the lead had been melted away from the inside of these barrels, the experiments were continued with all three; the balls, however, being placed at the muzzles. This proof commenced with 1 ball and a charge of 0.5 'ort,' (1 scruple 16 grains,) and ceased when the charge had been increased to 6 'ort' (7 drams 11 grains) and the number of balls to 5.

"In the following minutes the results of the experiments are more fully stated.

"Subsequently, 3 finished barrels, Nos. 1808, 2511, and 2635, were loaded and discharged.

"Barrel No. 1808, after having been subjected to the ordinary proof, was discharged with the usual sharp cartridge, and a testing-ball, placed 27 'tum' (31½ inches) from the chamber-end of the barrel. The only result was, that a considerable protuberance was produced at the seat of the ball.

"Barrel No. 2511 (rejected on account of defective make) was subjected to a similar proof, with the same result.

"Barrel No. 2635 burst in the proof. In this experiment a testing-ball was employed, and the charge was increased from 1 'ort' (1 dram 12 grains) to 16 'ort,' (2 ounces 3 drams 10 grains,) when the barrel burst, after having borne fourteen times the charge for which it was constructed.

"Carl Gustaf's Stad, the 25th day of May, 1872.

"F. G. TREFFENBERG,
"*Lieutenant in the Royal Göta Artillery,*
"*Working-Officer at the Carl Gustaf's Stad Gun-Manufactory.*"

Minutes taken, May, 1872, at the proving of gun-barrels (Nos. 1, 2, and 3) manufactured at the Fagersta Steel Works.

Number of discharges.	Weight of the charge in Swedish "ort," (1 ort=1 dram 12 grains, avoirdupois.)	Number of balls.	Observations.
1	4.5	1	Barrels unaffected.
2	9	1	A slight enlargement was produced in all the barrels at the seat of the ball.
3	9	2	The above-named enlargement was increased, and the caliber on each side of the seat of the ball was also somewhat increased; in addition to which, at the fourth discharge of barrel No. 3, a protuberance was produced before the seat of the ball.
4	9	3	
5	9	4	
6	9	5	
7	9	6	
8	9	7	
9	9	8	
10	9	9	The powder-gas escaped through the touch-holes of barrels Nos. 1 and 2, without the balls being removed from their seats; while in barrel No. 3 the balls were discharged.
11	9	9	Only barrels Nos. 1 and 2 were loaded and discharged, with the same results as in the preceding proof.
			With the balls at the muzzles of the barrels.
1	0.5	1	The powder-gas escaped through the touch-hole.
2	1	1	The balls were discharged; the barrels unaffected.
3	1	2	Do.
4	1	3	An enlargement was produced in the barrels at the seats of the balls.
5	1	4	The powder-gas escaped from the touch-hole of barrel No. 2
6	2	4	The balls were discharged from barrel No. 2.
7	2	5	The powder-gas escaped from the touch-hole of barrel No. 3
8	3	5	The powder-gas escaped from the touch-hole of barrel No. 1.
9	4	5	A protuberance was produced in barrel No. 3 at the seat of the ball.
10	5	5	A protuberance was produced in barrel No. 1 at the seat of the ball.
11	6	5	A protuberance was produced in barrel No. 2 at the seat of the ball.

Carl Gustaf's Stad, 25th May, 1872.

F. G. TREFFENBERG,
Lieutenant in the Royal Göta Artillery,
Working Officer at the Carl Gustaf's Stad's Gun-Manufactory.

"On the 27th of March, 1869, a steel gun-barrel manufactured at the Fagersta Steel-Works was subjected to testing-experiments at the Husqvana Gun-Manufactory, in the presence of the undersigned, and during the progress of the experiments the following observations were noted:

"1st proof: A charge of gunpower 1½ 'lod,' (5 drams 1 scruple 16 grains avoirdupois,) 1 testing-ball.

"2d proof: A charge of gunpowder 3 'lod,' (1 ounce 3 drams 12 grains,) 2 testing-balls.

"3d proof: A charge of gunpowder 3 'lod,' (1 ounce 3 drams 12 grains,) 3 testing-balls.

"The above three proofs were discharged without any remarkable result.

"4th proof: 3 'lod' (1 ounce 3 drams 12 grains) of gunpowder, 4 testing-balls. Result: The powder-gas escaped through the touch-hole, the balls remained in the barrel, and had to be removed by melting.

"5th proof: 4½ 'lod,' (2 ounces 2 scruples 8 grains) 4 testing-balls. No effect on the barrel.

"6th proof: 1½ 'lod' (5 drams 1 scruple 16 grains) of gunpowder-

One ball was forced into a position of 7½ 'verktum' (7⅓ inches) from the muzzle. Result: A protuberance in the form of an egg was produced in the barrel, at the seat of the ball.

"7th proof: 3 'lod' (1 ounce 3 drams 12 grains) of gunpowder. A ball was driven into a position of 1 'verktum' (1 inch) from the muzzle. Result: The same as in the previous proof, viz, the barrel was enlarged at the seat of the ball.

"8th proof: 3 'lod' (1 ounce 3 drams 12 grains) of gunpowder. The ball at the muzzle. Result: The enlargement above described, produced by the seventh proof, was extended by the eighth proof almost to the muzzle.

"Notwithstanding the barrel, after the discharge of each of the above proofs, was carefully examined, no other results could be discovered than those above described.

"Lastly, it should be observed that the balls employed weighed originally 6.65 'ort,' (7 drams 2 scruples 18 grains,) but after they had been forced into their positions, and, consequently, part of their substance had fallen off, they only weighed 5.50 'ort,' (6 drams 1 scruple 15 grains.)

"Husqvarna, dated as above, and signed by B. Munck, colonel, retired; Emil Ankarcrona, managing director of the Husqvarna Gun-Manufactory; C. E. Norström, lieutenant-colonel; A. J. Gustafsson, inspecting armorer; J. Holmberg, gunsmith; Anders Herrlin, inspecting officer."

124. KIRKALDY'S EXPERIMENTS UPON FAGERSTA STEEL.—Four large glass cases in the rotunda are filled with the specimens of Fagersta steel in different forms, just as they came from the testing-machines of Mr. David Kirkaldy in London. They exhibit the effects of pulling, shearing, and twisting stress, and are described and illustrated in an elaborate memoir by Mr. Kirkaldy, entitled "Results of an experimental inquiry into the mechanical properties of steel of different degrees of hardness and under various conditions; manufactured by Christian Aspelin, Esq., Westanfors and Fagersta Works, Sweden."*

This memoir is elegantly printed and illustrated, and is not only important to engineers and those using steel in construction, but is extremely interesting to the physicist. As an example of the nature of the investigation and of the results obtained, diagrams (Figs. 59 and 60) of two of the steel plates are here given.

These plates, before being subjected to strain, were 10 inches wide at the reduced part, and both edges were accurately parallel for 10 inches of length, and accordingly equal to the breadth or width at the reduced part. The seven holes at each end for connecting the plate to the massive steel links of the testing-machine were carefully and a curately made in line, and to fit the steel pins exactly. In order develop or make manifest the change of form of the plates when und stress, some of the plates had circles and others diagonal lines drawn the surface. The distortion of these lines shows the extent of the yiel ing of the plate in its different parts.

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* By David Kirkaldy. Illustrated by plates and wood-cuts. London, Testing and Experimental Works, Southwark street, S. E. 1873. 4°. Pp. 29, with tables and illustrations.

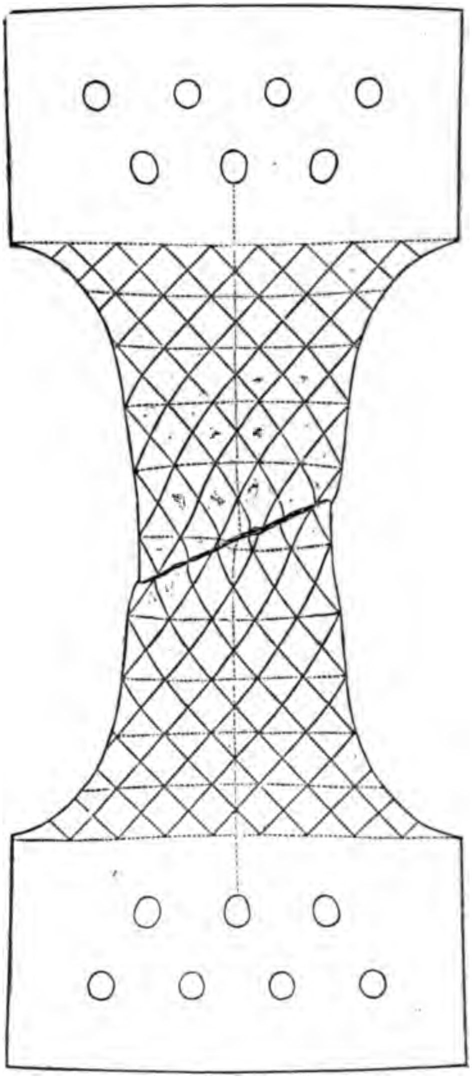

FIG. 59.—H. 1927.—Diagrams of steel plates broken by pulling stress.

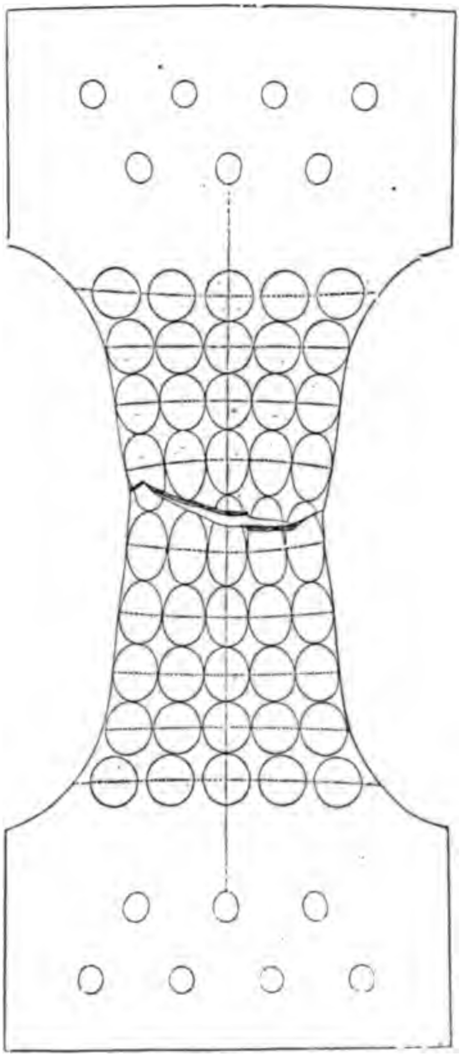

Fig. 60.—H. 1924.

g. 59, with the diagonal lining, represents the annealed plate, (H of the series,) and the plate (Fig. 60) upon which the circles were rn (H. 1924) was not annealed. Both plates were half an inch thick. results are tabulated with others in the annexed table.

125. *Deportment of rolled Fagersta steel plates under pulling-stress.*

LARGE SPECIMENS—TEN INCHES WIDE. LENGTH=BREADTH.

Description.	Marked.	Test-number.	Original size.	Original area.	Elastic stress per square inch.	Ultimate stress per square inch.	Ratio of elastic to ultimate.	Contraction of area at fracture.	Extensions, sets at— 40,000 pounds per square inch.	Extensions, sets at— Ultimate.	Appearance of fracture.
	No. in.	*H.*	*Inches.*	*Sq. in.*	*Lbs.*	*Lbs.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
Unannealed	1. 1/8	1906	9.95 × .129	1.283	53,300	74,915	71.1	43.1	0.00	10.8	100 per cent. silky.
	1. 1/4	1912	9.95 × .250	2.487	37,900	60,480	62.7	48.5	0.22	28.2	Do.
	1. 3/8	1918	9.95 × .380	3.781	29,500	51,456	57.3	59.3	7.33	36.1	Do.
	1. 1/2	1924	9.95 × .495	4.925	31,100	55,803	55.7	50.0	5.82	36.4	Do.
	1. 5/8	1930	9.95 × .625	6.218	28,000	52,924	52.9	55.1	6.66	37.2	Do.
Annealed..	2. 1/8	1909	9.95 × .124	1.233	35,500	57,485	61.8	57.1	1.11	22.9	Do.
	2. 1/4	1915	9.95 × .255	2.537	33,800	54,543	62.0	60.9	3.90	33.8	Do.
	2. 3/8	1921	9.95 × .380	3.781	28,900	51,076	56.6	63.4	7.39	35.8	Do.
	2. 1/2	1927	9.95 × .490	4.875	27,800	51,338	54.2	61.0	8.70	38.5	Do.
	2. 5/8	1933	9.95 × .628	6.248	25,500	50,432	50.6	62.0	9.98	34.4	Do.

There were several very interesting examples of the effects upon steel plates by pushing them through apertures of less than their own diameter, giving cup or bell shaped objects, highly sonorous, and suitable for gong-bells. This lot of specimens formed Series G of Kirkaldy's memoir, and he describes them as follows:

"*On the effect of bulging-stress on rolled steel plates of various thicknesses.*—The specimens for the above test were disks, twelve inches diameter, cut out in a lathe, and pressed through an aperture ten inches diameter in my testing-machine, the end of bulger being turned to a radius of five inches. The two wood-cuts which accompany the tabulated report of the results Series G, show the form of the specimen previous to and after experiment. Ten pieces were tested as rolled unannealed, and ten after being heated and annealed.

"The following table exhibits the stress required to force the specimens of the various thicknesses through the aperture:

Thickness.	5/8	1/2	3/8	1/4	1/8
Unannealed ....pounds..	215,685	162,735	104,845	71,800	35,397
Annealed ....do....	198,005	154,230	95,605	59,425	25,435

"All the specimens stood the ordeal without the slightest sign of any crack or defect in the manufacture. The clear tone given out, on being struck, by all the specimens after being bulged, excepting those that buckled owing to their thinness, proves the soundness of the material, and consequently its special suitability for some engineering purposes, as well as for bells and gongs. It is only superior ductile materials that will stand this test without cracking or showing signs of laminations or blisters. Circles were drawn on one of the flat disks, H. 1904, and it is curious to observe the change in their form according to their position, some parts being distended, while the portion toward the circumference is compressed; the original circumference of the specimen being 37.68 inches, and that of the aperture 31.40; difference, 6.28 inches, or 16.6 per cent., which is the amount of compression at the oute edge of the bowl. The material at the inner edge is still more compressed, the amount varying with the thickness. Thus we find in the five-eighth-inch plate the inner diameter is 8.9 inches; circumference, 27.94; difference, 9.74 inches, or 25.8 per cent.; and the depth 3.44 inches at the center of the bowl."

126. WIKMANSHYTTA STEEL.—The Wikmanshytta cast steel is claimed to be especially valuable for mint-dies and for tools, as attested by several certificates, two of which, from Joach. Ackerman, the chief director of the royal mint, containing interesting details regarding the tempering and wear of dies, are translated:

"Upon application made to me to that effect, I do hereby certify that cast steel, made at the iron-work Wikmanshytta, has been almost exclusively employed for coin-stamps in the royal mint of this place for upward of two years, and was found quite as proper to that purpose as the several kinds of foreign cast steel, both English and German, which, during the ten preceding years, have been imported for the use of the mint, as being the then best known steel for the same purpose. In the last five months of the year 1864, when copper coin only, of three different sizes, was manufactured, the stamps or dies of Wikmanshytta cast steel sustained upon an average 30,048 strokes each, and it should here be observed that such copper coin is somewhat harder than the Swedish silver coin of six ounces. As something extraordinary, I beg to state that one pair of stamps—for pieces of 4 riksdaler—have respectively sustained the following number of strokes by the mint-press, viz, that for the reverse side of the coin 90,000, and that for the obverse side more than 130,000 strokes, without either showing the slightest sinking or crack; and both of them were at last rejected owing merely to the fact of the flatter places in the engraving having become worn and indistinct by being repeatedly polished. Of the eight different degrees of hardness, wherein the Wikmanshytta cast steel is assorted, that marked with No. 1 has been found to be the most proper for coiners' stamps.

"Stockholm the 18th of March, 1865."

"I, the undersigned, do hereby certify that during the last five years no other cast steel than that of Wikmanshytta, marked C. R. U. I., has been employed for coin-stamps in the royal Swedish mint at this place, and that the said cast steel, as to strength and durability of the stamps, is found to be superior to the English cast steel of the best known kinds and marks, which were previously employed at the mint for the same purpose; and that it is quite as good as the famous Krupp's cast steel, which, especially manufactured for coin-stamps, was employed for more than one year, whereupon it was again given up on account of its high price. In the course of a coining, commenced some days ago, of brass pieces of 5 öre, with the same alloyage as that of the imperia French brass coin, a pair of stamps have already sustained 75,000 strokes without showing the slightest defect. Many years ago some large, hardened pieces, belonging to our coining-presses, were made of the same kind of cast steel from Wikmanshytta, and were fitted into the presses, instead of like pieces of other steel which were worn out or split, and the same have proved to be durable and are still perfectly faultless. The individual actually intrusted with the process of tempering the coin-stamps, and who is a clever and intelligent smith, operates as follows: The stamps (one or two to three stamps together) are packed up into a hardening-box of iron plate, in a fine charcoal powder, and are surrounded with clay uppermost at the mouth of the box, still so that their bottoms or lower surfaces, which are turned up, rest free and uncovered. They are then heated by a coal-fire in a small draught-furnace, and when they have the proper temperature, which is ascertained by their color, they are taken up and are refrigerated with pure water in a hardening-tub, from the bottom whereof a feeble dash of water rises against the piece to be hardened through the water standing in the tub, to the height of about 0.75 foot. The stamp is plunged into the water only little by little, in the first place almost nothing but the neck, and then the other part gradually, but the bottom itself is cooled more slowly, without being plunged down into the water. After being fully refrigerated, the stamp is annealed in the following way; that is to say, a suitable thick iron ring, heated to a slight degree of redness, is slowly drawn over the stamp and is kept there until the engraved surface has assumed a yellow straw-color, whereupon the ring is taken off, the tempering having then been finished.

"Stockholm, the 19th November, 1867."

This cast steel is produced by the Uchatius method. Granulated pig-iron is mixed with charcoal and powdered iron-ore of great purity and richness. It is melted in graphite crucibles.

CONDITION OF THE IRON-MANUFACTURE IN SWEDEN.

127. The condition of the iron-manufacture in Sweden at the beginning of the year 1873 is the subject of an important memoir by Prof. Richard Ackerman, assistant in the Mining Academy at Stockholm, prepared to accompany and elucidate the exhibition of Swedish ores, iron, and steel. The memoir may, therefore, be considered as a part of the exhibition, and this, together with its general value to the industry of iron, justifies the presentation of a translation in this place.

128. ACKERMAN'S MEMOIR—TRANSLATION.—Although the Swedish iron-manufacture has been developing steadily, both as to the quality and as to the quantity of the iron produced, still, it cannot be denied that at present Sweden no longer holds the prominent place among iron-producing countries as formerly. This, as will be shown, has been brought about chiefly by natural conditions, which have hindered the

iron-industry; still, Sweden keeps pace with many other countries more densely populated and richer in coal. Sweden, however, is just now in a state of transition to a new period of development, during which, it is reasonable to hope, the iron-manufacture will be brought to as high a degree as is possible in a country which has no mineral fuel in the neighborhood of its deposits of ore.

Far from the quality of the Swedish iron having deteriorated, it has become, in consequence of improved methods of production, not only purer and more uniform and dense, but also has been produced in greater quantity than formerly; for example, the production in 1870 was more than one and one-half times greater than in 1860. In comparison with many other countries it is still very small, in addition to which is the fact that, with a few exceptions, the iron destined for exportation has hitherto been produced only in the form of pig, bloom, bar, or refined iron. The Swedish iron is therefore only occasionally brought to market in manufactured forms, and the manufacture of iron-ware, with the exception of nails, has never been great enough to supply the necessities of the country itself.

129. *Distribution of iron-ores in Sweden.*—The cause of Sweden's producing so little iron does not lie in the lack of ores, for the country, on the contrary, is rich in iron-ore, although its profitable occurrence is limited to certain districts.

The greatest and most extensive deposit of ore is found in a belt running from northeast to southwest, which comprises the southern part of the provinces of Gefleborg and Kopparberg, the northwestern part of Westmanland, the northern part of the province of Örebro, and the eastern of Wermland. Including in this belt Winkärn, in the province of Kopparberg, no other deposit of importance is met with to the north, till as far as Norrbotten, where, indeed, at Gelliwara, and in other places, a great abundance of ore is found. In consequence, however, of injurious compounds, and the scanty population of these regions, up to this time the mines have been worked to only a very slight extent. South of this belt there are very important mines, as Dannemora, in the province of Upsala, and several others in the provinces of Stockholm, Södermanland, and Östergötland. Further still, near the southern end of the Wetter-see, in the province of Jönköping, occurs a great deposit, that of the Taberg. This province borders on that of Kronoberg, rich in bog-iron ores, which are also met with in several other provinces, though in smaller quantity.

Although the richness in ore is thus very considerable, most of the mines at present are not in a condition to yield greater quantities of ore annually, this condition being in turn dependent upon the fact that the demand for ore has been hitherto so limited that the necessary quantity could easily be furnished with the old apparatus. These relations are about to undergo an essential alteration, and the continually increasing consumption of ore will surely demonstrate soon the necessity for a more rational mining-system.

The first condition of sensible mining is that each mine shall belong to not more than one company, while it now happens that one mine is often divided into several parcels, each one of which is worked rather independently, and without proper connection with the other parts, by the different proprietors. Indeed, within the last few years many such pits opened on one mine have come into the possession of one company; but there is much to be done in this direction before the mining-system can reach such a point as to guarantee for the future a sure production of ore, both extensive and cheap.

130. *The sources of fuel.*—In order to bring about a greater production of iron, it is not enough to possess rich sources of ore; the amount of fuel necessary for the smelting and further working of the iron must also be present. It is precisely the small supply of this important element in iron-making which limits the iron-production of Sweden, for mineral coal occurs only in the most southerly part of the country, at Schonen, and possibly also in Southern Halland. The deposits of coal occurring there belong, apparently, to the Liassic, or perhaps to the upper and most recent part of the Triassic formation; which of the two cannot be determined with certainty from the petrifactions hitherto found.

It is not impossible in Schonen that coal may be present under, or perhaps in, the calcareous formation; how it is related to it is not yet fully made out. At Höganäs, and in a few other places in the northwestern part of Schonen, coal was found as early as the seventeenth century, in small quantity to be sure; so in the earliest times extensive and thorough explorations of the coal-formation of these regions were begun. In the remaining part of Sweden, unfortunately, one cannot hope to meet with coal, since, with the exception of the regions named, the rocks which form the body of the country belong partly to the Laurentian or primitive formation, and partly to the Silurian system, while the later deposits, except a few metamorphic areas, belong exclusively to the latest geological age.

The iron-ores (magnetite and hematite or specular ore) which are usually met with elsewhere in Sweden, do not occur in Schonen; though it is by no means impossible that in searching for coal an argillaceous iron-ore* may be found, and in that case, if the coal of Schonen should prove suitable for the blast-furnace, this province would enter upon a flourishing iron-industry. If, on the other hand, no important deposit of argillaceous iron-ore be found, still the coal of Schonen, if on better acquaintance it justifies the hopes now placed in it, would be of essential value to the iron-manufacture of Sweden, although the considerable distance (about 530 kilometers) of that province from the great iron ore belt would essentially lessen its value.

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*An inconsiderable deposit of such ore has been already discovered at Höganäs, which gave by the crucible-assay 39.5 per cent. of pig-iron with 0.13 per cent. of phosphorus.

In the future, be it as it may, Sweden is still pre-eminent in the working of her ores, both with the fuel which the forests and peat-bogs afford and that imported from other countries, for the refining of the iron produced.

131. *Transportation.*—The deposits of ore are by no means, as has been shown, uniformly distributed over the whole country; the densely wooded Norrland, for example, is wholly lacking, as far as is now known, in abundance of ore, with the exception of the province of Gefleborg, and the deposits at Gellivara, Lousavara, and a few other places in the northern part of the country. The same holds good also in a greater or less degree for many other forest-regions of the country.

It is, moreover, an undeniable truth that an important iron-industry cannot come into existence without convenient and ready means of intercourse, even in a country rich in coal. This must be the case to a much greater degree when the fuel necessary for the working of the ore must be brought from great distances, as here, where it consists entirely of forest-products. It is also a simple thing commonly to unite large deposits of coal with neighboring, or at least not very far distant, deposits of ore by means of railroads; but scattered forest-regions lying far from the mines are not so easily traversed by railways in order to bring the products of the former to those of the latter, and this is especially difficult in a thinly-populated country like Sweden. In this country, with an area of 445,000 square kilometers, or 8,079 square miles, of which 37,380 square kilometers, or 679 square miles, are water, according to the census of 1871 there were only 4,204,177 inhabitants, by far the greatest part of whom dwelt in the southern half of the country. Taking away the province of Gefleborg, the remaining part of Norrland, with an area of 243,700 square kilometers, or 4,425 square miles, has no more than 378,754 inhabitants. The southern and smaller part of Sweden, in 1871, had less than 3,820,000 inhabitants, and it is not surprising, therefore, that it was long feared that no railroad would be profitable here. Experience has shown that this fear was groundless, and very important railways have been finished during the last year.

At the end of 1871 there were 1,885 kilometers of railroad in operation; of these, however, 1,187 kilometers were main-trunk railways, and only occasionally touched the ore-districts, but, as main routes, aimed to unite certain important places as directly as possible. On the other hand, during the last year so many new railway-works were finished that at the end of the year 1872 about 2,100 kilometers of new railroads were in process of building, of which a very considerable part were mining railways.

Considering Sweden in a measure well provided with railways, still the iron-production, as regards quantity, cannot increase greatly in comparison with other countries, unless a hitherto unknown greater deposit of ore be discovered near the coal in Schonen; for only on this supposition can the expense of a production of ordinary iron in great quanti ties for the market of the world be possible in Sweden. Without such a discovery of ore in Schonen, Sweden must limit herself henceforth to the production of the so-called "quality-iron." The impossibility of founding an iron-manufacture which shall be important in the present time is much greater for Sweden, since there the second growth of the forest takes place much more slowly than in various other countries.

Since the forest-products, by greatly increased facilities of communication, obtain a higher value, the forests will be better cared for in the future, and the revenue obtained from them will be greater than now. In the more remote forest-districts the peasant has done nothing at all for the second growth of the wood; but even under the supposition of the fulfillment of what has just been said, it still remains impossible to build up a great iron-industry with charcoal alone. Each kilometer of forest in the neighborhood of our works, when it receives the best care, yields annually only 275 cubic meters of hard wood, while a square kilometer of forest, as ordinarily cared for by the Swedish peasant, if it has not been wasted, yields often not more than 105 cubic meters of hard wood annually, and from a solid mass of wood is obtained, according to the care in burning, 90 to 100, often only 60 to 70, per cent. in volume of coal. If 7.8 cubic meters of charcoal (coal-dust, &c., included) are reckoned to the ton of pig-iron, and if in the future as good care is bestowed upon the forests in general as is now given to a few forest-properties, a wood-area of 2.8 hectares will be required to supply the fuel necessary for the production of the quantity of iron mentioned.

132. *Use of English coke.*—There is a possibility of the amount of iron produced increasing considerably by the use of English coke for the blast-furnace, and then refining the pig-iron thus obtained by the Bessemer process. An important advantage over the English cannot be claimed for such a Bessemer product; it would be equal to it, however, and quite good enough for rails, &c. Such a production of pig-iron, based on English coke, has been seriously considered in Sweden, and could be accomplished much more easily than the project of exporting Swedish ore to England, for the production of pig-iron. This is partly because the freight to England is much higher than the return freight, and partly because fully one and a half times as great a weight of ore is necessary for the production of pig-iron as of good coke.

Although the old iron-works, with the help of coke from England, or possibly from Schonen, could compete with the English Bessemer product in a wider range than formerly, still it is not possible to produce in this way an article equal to the ordinary English in price, and it will remain none the less impossible, therefore, for the old manufacturing regions to develop an iron-production actually great as regards quantity. In this there is no obstacle to prevent the amount produced hitherto increasing considerably, after the completion of railroads now building, and also others; and it will first become possible through these railroads to leave the beaten way, that of producing bar-iron almost exclusively, in order at the same time to make railroad-material, sheet-iron, &c., in greater quantity.

From what has been said already, the important advancement of the iron-production through railways must be evident; but the further proof of this matter is the fact that the forest-districts lying near the larger mines, which have been worked for a long time, through excessive cutting, have become in the lapse of time very much cut away, and the consequence is that the charcoal needed for the smelting of the ore must be brought from ever-increasing distances. With the aid of good communication, however, the amount of charcoal, which in the immediate neighborhood is beginning to fail, can not only be restored, but, by moderate cutting of the forest, far more coal than formerly can be made, since in many distant forest-regions the forest, until lately, has been wholly valueless,* and therefore has been very badly cared for, so that it has not yielded nearly the income which it might have done by judicious economy. In addition to this, it has been customary at distant saw-mills, with strange wastefulness, to burn, as useless, not only all the sawdust, but also all other rubbish, like bark, slabs, ends, &c.

It has been intimated above, and is shown more clearly by the following statistics, that the Swedish iron-works have, with few exceptions, produced till now almost exclusively bar-iron, or, in other words, merchant-iron. This circumstance may appear strange to a foreigner who is accustomed to seeing a ready ware, or at least partially-refined iron, produced at the works; but the chief cause of this, also, is to be sought for in the insufficient means of communication of the mining-districts. Pig-iron and bar-iron can be manufactured with profit in very small quantity, while this is not so much the case with railroad-material, since larger and more costly mills are necessary for that work, and they must have a considerable production in order to defray the first cost. For this it is indispensably necessary that considerable quantities of raw material can be brought to one point at a moderate price, which cannot be accomplished without good means of communication; in addition to which is the fact that a railway-connection is more necessary for iron-works which produce ready wares than for those which manufacture only merchant-iron, since the time of delivery is not usually so strongly limited for the latter as for the finished goods.

133. *Water-power.*—It is fortunate for the iron-manufacture of Sweden that the country is rich in water-power, small streams occurring in numberless quantity, on account of which all iron-works are located at water-falls. In the mining-districts also quantities of water occur which afford thousands of horse-power, and when these are connected by railroads with the mines and forest-regions they will afford the most suitable situations for greater iron-works, especially when great saw-

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* In some regions, even in the last year, charcoal has sold for 1.75 francs per cubic meter, while at certain mines it brought 7 francs per cubic meter; and under the present favoring circumstances it costs in some places 14 to 17 francs per cubic meter.

mills, as is now and then the case, are already situated on the same fall, for the iron-works can then use the refuse of the saw-mills without extra cost for transportation. Many iron-works intended for the production of railroad-material and sheet-iron have been located in such places within the last two years, and it is the intention to have them completed at the same time with the railroads leading to them.

The demand of the world's market for Swedish bar-iron is in fact very limited, for it is much too good for most purposes, and its value can therefore be properly estimated only for certain uses, as for making the best steel and a few manufactured wares like wire, horse-nails, &c. A cheaper and poorer iron, on the other hand, answers for most purposes, and as inconsiderable as the amount of production of the Swedish iron has hitherto been, it has still been able to satisfy all demands under ordinary circumstances; therefore an increased production of so expensive a merchant-iron as the Swedish for many years would only bring about a lowering of the price of iron. If an essential increase of the Swedish iron-production is to bring an actual advantage, it is indispensably necessary that new works for the production of other kinds of iron than bar-iron be built; and this has, as has been remarked, actually happened, and also many of the old bar-iron works are beginning to change to the manufacture of Bessemer and railroad-iron. The other works, which remain as formerly, will, in consequence of this, be able to depend upon so much the more certain sale of their product in the future.

After these more general considerations we will now pass to a more definite statement of the condition in which the Swedish iron-manufacture is at present.

134. *Geological association of the iron-ores of Sweden.*—The iron-ores of Sweden are chiefly magnetite and hematite, which are classed together as mine-ores, to distinguish them from the bog-ores and limonite which also occur, but are worked only in the province of Småland.

The magnetic ores by no means always correspond to the formula Fe_3O_4, but with one molecule of sesquioxide can contain more or less than one of protoxide. Sometimes more or less hematite is intermingled, as in the ore from "Stora-Bispberg." Sometimes the magnetite is so mixed with hematite that it is hard to say to which class it belongs. In some mines, also, these two kinds of ore occur in beds side by side, as at Grängesberg and Dalkarlsberg; usually, however, they are separate, so that the same mine only affords one of the two ores.

The mine-ores, or the magnetite and hematite, belong to the Laurentian or primary formation, and never occur in with gangue or veinstone, but as actual beds or strata, which have the same strike and dip as the surrounding rocks. Many deposits of ore possess no great extent, but soon thin out; if, however, the strike of the rock is followed, sooner or later a new deposit is met with, and in this way the same bed of ore can often be followed for a myriameter. Other beds of ore, on the other hand, often have a continuous extension in the direction of the strike, of many hundred meters, with a varying breadth.

The beds are sometimes sharply cut off and more or less displaced by transverse beds, so-called "skölar," of chlorite-slate, trap, or granite. Also, the thickness of the bed is very irregular, varying from an inconsiderable thickness to 30 or 40 meters. It is also very common to find the bed accompanied by several parallel strata of ore, which are separated by more or less barren rock.

The main mass of the solid rock of Sweden consists of granite and gneiss; considerable quantities of mica-slate are met with, and, in addition, hornblende-slate, "*halleflinta*," diorite, and granular limestone very often occur.

The iron-ores lie sometimes immediately in gneiss, as at Grängesberg, in the province of Kopparberg, and Norberg, in Westmanland; the gneiss itself is so poor in feldspar that it has been taken by some for mica-slate. When the ore lies in gneiss, the transition from barren rock to that containing ore is often very indistinct, and the ore then consists of a gneiss whose other constituents besides quartz are made up more or less of iron-ore. This is often the case with blood-stone, which consists usually of alternate layers of tolerably pure hematite and gneiss rich in quartz, and having iron-ore intersprinkled in it. These occur alternately, and the whole then consists of often many hundred parallel streaks of ore, between which stripes of quartz or gneiss lie. The smaller the latter are in proportion to the former, the richer the ore is.

Often these ore-deposits do not lie immediately in gneiss, but are surrounded by other rocks which themselves lie in gneiss. The envelope of the most considerable ore-beds consists of *helleflinta*, as at Dannemora, in the province of Upsala, or of a *helleflinta*-like gneiss, "eurite," as at Persberg, in Wermland. The ores are sometimes surrounded by mica-slate, as at Dalkarlsberg, in Örebro, and finally they are occasionally imbedded in granular limestone, as at Klackberge in Norbergs, in Westmanland, and at Långvik, in the province of Kopparberg. For the rest, the occurrence of lime in the ore-beds is very irregular. Finally, it is to be remarked that the ore-beds are often limited by peculiar mineral masses, so-called "skölar," in the hanging wall and in the footwall, which consist usually of chlorite and talc.

The dip of the Swedish ore-beds, like that of the surrounding rock, is, in consequence of the many flexures of the strata, very various; usually, however, it approaches more nearly the vertical than the horizontal plane. In addition to this side-dip, the ore-beds have very often a dip in the direction of the strike. As in the direction of the strike, so also sometimes downward, the beds thin out, but if the dip is followed down, a new mass of ore is usually met with sooner or later.

The blood-stone sometimes contains almost no other strata than quartz. Commonly, however, it is more or less mixed with other minerals, as pyroxene, hornblende, chlorite, epidote, garnet, and calx-spar.

This is still more the case with the magnetic ores, which are usually less acid, "dry," or rich in silica than hematite. Among the last named there are many which must be mixed with 30 per cent. or more of limestone in order to produce a bisilicate slag in the blast-furnace, to accomplish which, the magnetic ores seldom require more than 10 to 20 per cent. Often they need only a very small addition of limestone; and there are many ores which are self-fluxing, that is, they are associated with the above-named and other minerals in such proportions that they need no mixing with other ore, or with flux, for the blast-furnace. To these, among others, belong the Dannemora ore. Some ores are, finally, rich in lime, and are therefore mixed with the quartz-bearing "dry" ores; on account of which they are called "Gattirungssteine." These lime-bearing ores are, with few exceptions, magnetic, and often very manganiferous, like the ore from Långvik, which contains about 8 per cent. protoxide of manganese, and the magnetite from Klackberge, in Norberg, of which the Granrot ore contains 7 to 10 per cent. Mn O.

The iron richest in manganese, among those hitherto worked in Sweden, is the magnetic ore of the neighboring Svartberg, used at Schisshyttan, in the province of Kopparberg, for the production of spiegel iron. This ore contains 13 to 20 per cent. of protoxide of manganese, which is caused by the bed consisting for the most part of knebelite.* Among the very manganiferous iron-ores belongs the magnetite of the Penning-Grube, in the province of Gefleborg, containing 12 to 14 per cent. Mn O, and, likewise, an ore lately discovered in the Southern Hag-Grube, in Norberg, with over 30 per cent. Mn O.

The amount of iron in the Swedish ores varies between 30 and 70 per cent.; it is, however, usually about 45 or 50 per cent. Since lime-bearing ores are rarer than those with quartz, sometimes ores occurring in limestone, and having only 20 per cent. or less of iron, are worked; they are, however, always mixed with richer ores containing quartz before smelting.

Occasionally the ores are so rich in talc that not only limestone must be added before smelting, but also silica. Quartz alone is seldom used for this purpose, but ores containing quartz are added, of which there is seldom any lack.

The "mine-ores" contain usually very little phosphorus, and among those most free from phosphorus are the ores from Dannemora, in Upsala, with 0.003 per cent. of phosphorus, and from Persberg, in Wermland, with 0.004 to 0.005 per cent. phosphorus. Usually the amount of phosphorus varies between 0.005 and 0.05 per cent.; although there are some with a tenth of 1 per cent., as is the case with some of the richest iron-ores in the parish of Grangärdes and the neighborhood, and also with some of the peculiarly rich iron-ores high up in Norrbotten, as the Kerunawara and Gelliwara ores. In some of these ores as much as 1.5

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* Knebelite, a silicate of iron and manganese, containing about 35 per cent. of oxide of manganese.—W. P. B.

per cent. of phosphorus is found. Ores which contain more than 0.15 per cent. of phosphorus have been heretofore only occasionally worked, and then only when mixed with those free from phosphorus. In most cases the phosphorus seems to come from intermixed apatite, and with reference to some of the Grängesberg ores, rich in this mineral, it has been proposed to treat them in the wet way, in order to change the apatite into superphosphate.

The ores most free from phosphorus are usually employed for the production of iron for steel-manufacture, and, since the most of the Swedish iron used in England is destined to serve as material for steel-manufacture, its value has hitherto depended mainly on the absence of phosphorus. As the Swedish iron has become more uniform and dense since the introduction of the Lancashire method, it has obtained a more extended use for the finer kinds of manufacture, and the iron produced with the greatest carefulness has latterly brought almost as high a price as the better kinds of cement-iron. The value of the iron intended for manufacturing purposes is not nearly so dependent on the absence of phosphorus as is the case with cement iron, but if there is only a few hundredths, or, at most, only 0.10 per cent. of phosphorus, then only the compactness and uniformity of the iron are considered, which properties are of most value for manufacturing purposes, and for this reason ores which contain only a few hundredths of a per cent. of phosphorus are most advantageously used for the production of this kind of iron.

Besides the ores most free from phosphorus, the manganiferous ores are advantageously employed for the production of cement-iron, and it is the main point to choose the most suitable ores for steel-production, while less care can be used in the refining process since compactness and uniformity are less necessary properties of the cement-iron. The contrary is the case in the production of manufacturing iron, since here these properties play the most important part, and the perfection of the same is dependent on the care which is employed in the refining; still it can by no means be said that an ore having still less phosphorus would not be of value for certain manufacturing purposes, and, in fact, ores much more nearly free from phosphorus are used in Sweden for the production of merchant-iron.

The mine-ores are almost always intermixed with more or less pyrite, and sometimes with other metallic sulphides, yet in most cases any considerable amount of sulphur in the ore can be removed by careful roasting. For this purpose shaft-furnaces, heated by the gas from the blast-furnace, are almost exclusively employed, and among the best of these are those constructed by E. Westman, in which so high a temperature may be obtained that the most difficultly fusible ores sinter together. These roasting-furnaces, which are shown in drawings and described in "*Ausführliches Handbuch der Eisenhüttenkunde von* J. Percy, *bearbeitet von* H. Wedding, 2 *Abtheilung*, p. 485," have, on account of their great superiority, supplanted the old gas-roasting furnaces, and now many ores which were before wholly useless can be employed.

Some iron-ores contain much titanium; yet the titanium is usually considered an unwelcome constituent of the ore, since it makes it so difficult of reduction, and the consumption of fuel in smelting titaniferous ores is so great. Among these ores the magnetite from Taberg, in the province Jönköping, deserves special mention, since it is different from the other Swedish ores in many respects. It is not, like most other iron-ores, collected together by itself, but the grains of ore occur so finely intersprinkled in a dark serpentine that it is impossible to separate them from it. This ore forms a whole mountain of 120 meters height and about 2,600 meters length, yet the amount of iron is not greater than about 30 per cent. Besides, this ore contains fully 6 per cent. of titanic acid and some vanadium, which was first discovered by Sefström in iron which was made directly from this ore.

More accurate information in regard to the composition of many Swedish iron-ores may be obtained from the tables of analyses:

135. *Production of iron-ore.*—In the year 1871 the yield of mine-ores was 647,119,000 kilograms, as follows:

In the province of Norrbotten, (Gelliwara,) 21,265 kilograms.
In the province of Wester-Norrland, (Ulfö,) 928,855 kilograms.
In the province of Jemtland, 15,736 kilograms.
In the province of Gefleborg, 22,444,697 kilograms,
viz, 13,235,200 kilograms from Nyäng, in the parish Thorsåker.
989,600 kilograms from the Erik-Ers-Grube, in the parish Thorsåker.
1,980,700 kilograms from Penning Grube, in the parish Thorsåker.
1,177,700 kilograms from the Sjöhag-Grube, in the parish Arsunda.
1,745,400 kilograms from the Rödäng-Grube, in the parish Ostra Fernebo.
In the province of Upsala, 33,132,273 kilograms,
viz, 21,405,500 kilograms from Dannemora, in the parishes Films and Dannemora.
1,003,700 kilograms from Ragnhild, in the parishes Films and Dannemora.
1,173,300 kilograms from Stenring, in the parish Morkarla.
3,991,200 kilograms from Ramhäll, (Hammarin,) in the parish Alunda.
3,143,800 kilograms from Sahlsta, in the parish Lena.
1,798,000 kilograms from Brunna, in the parish Lena.
In the province of Stockholm, 29,367,688 kilograms,
viz, 3,474,700 kilograms from Vigelsbo, in the parish Vahlö.
2,934,600 kilograms from the Sandgrube, in the parish Börstil.
5,146,100 kilograms from Skedika and Grind, in the parish Börstil.
1,385,600 kilograms from Björsta, in the parish Harg.

2,807,000 kilograms from the Slottsgrube, in the parish Söderby. Carl.

4,995,700 kilograms from Herräng, in the parish Häfverö.

7,842,200 kilograms from Utö, in the parish Österhanninge.

he province Kopparberg, 178,046,656 kilograms,

viz, 1,020,200 kilograms from the Dvarnbacks-Gruben, in the parish Leksand.

21,142,200 kilograms from Vinkärn, in the parish Svärdsjö.

1,053,400 kilograms from the Sjö-Grube, in the parish Svärdsjö.

1,839,700 kilograms from Skinnaräng, in the parish Vika.

859,100 kilograms from Harmsarf, in the parish Kopparberg

3,100,400 kilograms from Hästberg, in the parish Stora Tuna.

9,055,200 kilograms from Romme, in the parish Stora Tuna.

2,674,400 kilograms from Bräfall, in the parish Stora Tuna.

12,870,800 kilograms from Stora-Bispberg, in the parish Säter.

1,080,400 kilograms from Vestra-Bispberg, in the parish Säter.

1,531,600 kilograms from the Tägt-Grube, in the parish Säter.

3,469,400 kilograms from Knappkärn, in the parish Hedemora.

1,359,900 kilograms from the Öster-Grube, in the parish Gustaf.

12,554,500 kilograms from Rellingsberg, in the parish Husby.

2,505,900 kilograms from Rullshyttan, in the parish Garpenberg.

1,324,400 kilograms from Långvik, in the parish Garpenberg.

2,683,000 kilograms from Svartfjäll, in the parish Garpenberg.

24,859,200 kilograms from Ormberg, in the parish Grangärde.

5,086,600 kilograms from Grängesberg, in the parish Grangärde.

4,629,000 kilograms from Risberg, in the parish Grangärde.

1,605,100 kilograms from Fäbobacken, in the parish Grangärde.

7,820,600 kilograms from Finnäs, in the parish Ludvika.

2,129,200 kilograms from Fredmundberg, in the parish Ludvika.

7,598,000 kilograms from Gräsberg, in the parish Ludvika.

9,318,500 kilograms from Håksberg, in the parish Ludvika.

4,338,100 kilograms from Östanberg, in the parish Norrbärke.

7,360,400 kilograms from Nyberg, in the parish Norrbärke.

3,282,300 kilograms from Gesberg, in the parish Norrbärke.

4,999,600 kilograms from Svartberg, Marnäs, in the parish Norrbärke.

7,481,900 kilograms from the Svartberg, Svart-Grube, in the parish Norrbärke.

884,800 kilograms from Siksjöberg, in the parish Norrbärke.

1,275,900 kilograms from the Slät-Grube, in the parish Norrbärke.

2,344,500 kilograms from Hilläng, in the parish Norrbärke.

the province of Westmanland, 92,225,667 kilograms,

viz, 27,716,600 kilograms from Risberg, in the parish Norberg.

16,112,500 kilograms from Morberg, in the parish Norberg.

20,138,500 kilograms from Klackberg, in the parish Norberg.

6,044,000 kilograms from Uddevalla, in the parish Norberg.
1,457,800 kilograms from the Badstugu-Grube, in the parish Norberg.
948,400 kilograms from the Norr-Grube, in the parish Norberg.
4,191,300 kilograms from the Ny-Grube, in the parish Norberg.
2,750,800 kilograms from the Finn-Grube, in the parish Skinnskatteberg.
3,585,300 kilograms from Bastnäs, in the parish Skinnskatteberg.
1,003,500 kilograms from the Kulle-Grube, in the parish Skinnskatteberg.
2,216,700 kilograms from the Backe-Grube, in the parish Skinnskatteberg.
3,431,500 kilograms from Lugndal and Springan, in the parish Sala.
1,264,400 kilograms from Åby, in the parish Sala.

In the province of Öubro, 135,690,051 kilograms,
viz, 4,014,000 kilograms from Lomberg, in the parish Nya Kopparberg.
7,431,900 kilograms from Svartvik, in the parish Nya Kopparberg.
995,200 kilograms from the Limbergs, Moss-Grube, in the parish Nya Kopparberg.
7,065,900 kilograms from Strossa, in the parish Ramsberg.
2,479,700 kilograms from Blanka and the Kärr-Gube, in the parish Ramsberg.
14,290,100 kilograms from Stripa, in the parish Linde.
2,505,400 kilograms from Grönvold, in the parish Linde.
2,598,400 kilograms from Bredsjö, in the parish Hjulsjö.
2,114,300 kilograms from Ånnenäs in the parish Hjulsjö.
1,410,500 kilograms from the Stora Björnhöjde-Grube, in the parish Hjulsjö.
3,408,400 kilograms from Högborn, in the parish Grythytte.
14,057,400 kilograms from Dalkarlsberg, in the parish Nora.
3,522,300 kilograms from Vikers, in the parish Nora.
8,467,700 kilograms from Pershyttan, in the parish Nora.
27,676,000 kilograms from Striberg, in the parish Nora.
6,592,100 kilograms from Ryngshyttan, in the parish Nora.
8,141,100 kilograms from Klacka, in the parish Nora.
2,792,500 kilograms from Fogdehyttan, in the parish Nora.
2,576,900 kilograms from Hvilare, in the parish Nora.
2,926,100 kilograms from Slotterberg, in the parish Jernboås.
3,423,700 kilograms from Finnshyttan, in the parish Jernboås.

In the province Wermland, 121,252,392 kilograms,
viz, 13,487,100 kilograms from Nordmark, in the parish Nordmark.

11,560,100 kilograms from Taberg, in the parish Nordmark.
5,382,200 kilograms from Finnmossan, in the parish Nordmark.
8,327,800 kilograms from the Eng-Grube, in the parish Fermbo.
52,972,000 kilograms from Persberg and Yugshyttan, in the parish Fermbo.
5,886,200 kilograms from Långban, in the parish Fermbo.
3,330,300 kilograms from Kroppa, in the parish Kroppa.

In the province Södermanland, 19,231,386 kilograms,
viz, 4,529,400 kilograms from Högsjö and Staf, in the parish Floda.
3,412,600 kilograms from Sofia, Wilhelmina, and Mosstorp, in the parish Sköldinge.
2,564,700 kilograms from Kantorp, in the parish Sköldinge.
1,275,900 kilograms from Porthål, in the parish Gåsinge.
3,621,900 kilograms from Förola, in the parish Svärtuna.
1,833,000 kilograms from Gillinge, in the parish Svärtuna.

In the province Ostgothland, (Natorp, in the parish Skällsvik,) 4,450,169 kilograms.

In the province Calmar, 382,770 kilograms.

In the province Jönköping, 9,910,128 kilograms, of which 9,457,300 kilograms were from Taberg, in the parish Måusarp.

In the province Kronsberg, 19,266 kilograms.

In the iron-mines, there were employed in the year 1871 4,191 steady workmen, 436 periodical workmen, 312 women and children—total, 4,939 persons.

136. *Methods and costs of mining.*—The miners work by contract, and in a few places are paid according to the amount of ore obtained, but usually according to the length of drift excavated. Sometimes these two methods are combined in such a way that the owners of the mine pay according to the amount of ore obtained, and the money is divided among the workmen according to the length of each drift. Usually the miners earn from 2 to 4 francs a day; sometimes, under favorable circumstances, still more. Usually it is very difficult to fix the income of the miners accurately, for most of them enjoy certain advantages in addition to their mere wages, like free lodgings and firing, land for potatoes, fodder for a cow, &c.; only the workmen which at present have about 4 francs are without these advantages.

Usually the same workman manages the drill as well as the hammer, only in a few places does he make use of a special striker. The drifts are usually only 24 millimeters wide, and cost for drilling downward 1 to 2.5 francs per meter, according as the workman, in addition to his mere wages, enjoys other advantages or not; for drilling upward—"dry-boring"—it costs twice as much. Drill and hammer are now always steel. For blasting, either gunpowder, dynamite, or "ammonia-gunpowder," which latter consists of a mixture of about 20 per cent. nitro-glycerine with nitrate or picrate of ammonia and charcoal-powder, is used. Pur-nitro-glycerine has been used, and at some mines is considered the best blasting agent; the many accidents, however, which the latter has occasioned have had such an influence on its use that it is almost prohibited.

The amount of work done by each miner is naturally very various, since it depends partly on the degree of hardness of the ore, or more properly the bed, partly on the kind of work and wages, and, finally, on the blasting agents used, which must be determined by the character of the mine. The following numbers may be taken as the average: Usually 1.5 to 2 meters, sometimes 3 meters, are excavated, per day and man; in drilling upward, however, only about 1 meter, and 0.5 to 1.6 cubic meters, or about 1,300 to 3,800 kilograms of loose ore are obtained. Per kilogram of dynamite and ammonia-powder, 10 to 16 tons of loose ore are obtained, and per kilogram of gunpowder, 5 to 6 tons. The cost for the ore brought up and separated amounts to from 2.9 to 16 francs per ton.

Concerning the method of mining, that of mining by levels is most common. A shaft is sunk through the loose layers of earth possibly present, and deep enough into the ore-bed that the part of it passed through will form a safe roof, if side-galleries are to be established. The main shaft is continued downward, if the ore is to be taken out by levels, (*Strossenbaus*,) leaving, however, the necessary supports or piers to retain the walls of the mine.

The space excavated is usually left open and empty; but in a few mines, whose walls cannot be held by supports or piers, but must be strongly timbered on account of cracks and brittle places, they have begun to fill up the space with dead-rock, and then take out the ore from the top of the level, (*Firstenbau.*)

The last-named method is unnecessary in most of the Swedish mines on account of the solidity and strength of the rock, but it will probably come into use in the future more than at present, since many mines have become unsafe through lapse of time. A circumstance that considerably hinders the use of this method in Sweden lies in the fact that the amount of dead-rock necessary for filling up is almost never found in the mine, since about half of the whole mass of rock taken out is requisite.

When the ore is raised from the mine vertically, either wooden buckets bound with iron, or those made of Bessemer steel, are employed, which hold 0.165 cubic meter, or about 425 kilograms, of ore, and which are provided with wire-ropes for hoisting. When the ore is brought out at an angle, on the other hand, usually tramways or railways with little cars are used, which likewise are attached to wire-ropes. The water is raised by means of suction and lifting pumps, arranged under each other, each of which is nine meters long; in deeper mines, however, the more suitable force-pumps are found in use, with a forcing-power of about 180 meters. The greatest vertical depth of any of the Swedish iron-mines at present is 230 meters.

In the smaller mines one engine sometimes raises both the ore and he water; commonly, however, different motors are used for these puroses. Since Sweden, as has been remarked, abounds in rivers, at most f the mines water-power occurs, and in order to transmit the power om the water-fall to the mine, sometimes wooden shafts, sometimes opes, are used. Such shafts, which sometimes have a length of nearly ,000 meters, are very common for the transmission of power to the umps, but are seldom used for raising the ore; when the distance to he nearest water-fall is too great for the employment of ropes, for the tter purpose steam-power is used. Also for pumping water the latter ower must sometimes be employed, and there were in the year 1871, mong all the mines of Sweden, fifty-six steam-engines in use, most of hich, however, had only ten to sixteen horse-power.

That both the number and the power of the engines must be inreased is a natural consequence of the increasing depth of the mines, nd also of the increasing demand for ore; for a water-power which is ufficient to raise ore from an inconsiderable depth will be inadequate or greater quantities of ore and greater depths.

Owing to the above-mentioned causes, the annual consumption of re has been so small in proportion to the richness of Sweden in ore, hat enough could be obtained without difficulty, usually, and the price f ore at most of the mines has been so small (6.50 to 9.80 francs per on) that, with few exceptions, the aim of the proprietors of the mines as been to supply the small amount annually required with the least ossible expense. Such a method of procedure is in most cases irreconilable with a rational system of mining, and it is doubtful if such a ystem can ever be possible so long as the same ore-bed, standing nearly ertical, is not worked by one single company, but belongs to several ifferent owners, each of whom works his own shaft, and who may easily ome into collision with each other down below the surface. Besides, he available water-power in many great mining-districts is not suffiient for raising immense quantities of ore; it stands to reason, howver, that a much greater effect could be produced with it if the mines tood in connection with each other, so that the raising of the ore and he water could be concentrated in a few single shafts, instead of every eparate shaft having its own hoisting and pumping apparatus, as is ow often the case.

It is not strange, therefore, that the prospects of a better future for he iron-industry, opened by the high price of iron at present, and still ore by the railroads in process of construction, have caused a considrable rise in the price of iron-ores, which are now sold for 24 to 30 rancs and more per ton; in addition to this, it is to be hoped that inreased value of the mines will lead to a more rational mining-system han that hitherto in use, and many signs indicate that this hope will oon be fulfilled.

137. BOG-IRON ORE AND LIMONITE.—The bog-ores, which consist of

hydrated sesquioxide, are formations of the latest time, and are continually forming now. They occur in many provinces, and formerly were used for the direct production of wrought iron. They occur in the greatest quantity in the province of Småland, and are worked almost alone in this province; since they usually contain several tenths of a per cent. of phosphorus, cast iron only is made from them.

The bog-ores, which, according to their appearance, are called "Pulver-," "Perlen-," "Pfenning-," or "Kuchen-ore," form beds 0.75 meter thick, and occur usually in marshy places a short distance from the shores of the lakes. After the lakes are covered with ice they are taken out with long-handled shovels and steel sieves. The deposit gradually forms again, so that in about twenty years a new bed has formed in the same place. Owing to the necessity of obtaining the ore in the winter, this can never be of very great importance.

In the year 1871 15,769,444 kilograms of bog-ores were obtained, as follows: 127,590 kilograms in the province of Skaraborg; 555,527 kilograms in the province of Calmar; 8,911,864 kilograms in the province of Jönköping; and 6,174,463 in the province of Kronoberg.

138. PRODUCTION OF PIG-IRON.—As early as 1830 there was a "stückofen" or high bloomary furnace in operation in the province of Jemtland, but since this time, a few experiments excepted, wrought iron has not been produced directly from the ore; but the iron-ores are first reduced to pig-iron in a cupola-furnace.

Formerly the cupola-furnaces had but 1 tuyere and were 9 meters high; latterly, most of them are increased in height, and are provided with 2 to 4 tuyeres, and the newly-built furnaces have a height of from 12 to 16 meters. The height of the cupola-furnaces at present, therefore, varies between 9 and 16 meters, and their internal diameter between 1.5 and 1.9 meters at the top; 2 and 2.9 meters at the belly; 0.8 and 1.4 between the tuyeres. The internal capacity of the furnace-shafts varies between 23 and 90 cubic meters. Usually two, sometimes three or four, tuyeres are used; in a few furnaces there is still only one tuyere. The diameter of the tuyeres is usually, in two-tuyere furnaces, between 47 and 60 millimeters. The pressure of the blast varies between 24 and 90 millimeters of mercury; it is generally 36 to 60 millimeters. Blasts ranging from cold air up to air at 400° C. are used; in general, however, it is scarcely 200° C.

Charcoal is used almost exclusively as fuel in the cupola-furnaces. It is mixed with wood in a few furnaces, especially in Småland, 0.21 cubic meter of oak wood corresponding to about 1 Swedish ton, or 0.165 cubic meter of pine charcoal; at most, every third ton of coal is replaced by wood in this way. At Schissbyttan, where speigel iron is produced, Mr. Keiller has lately begun to employ wood in greater quantities, and the furnace has been built up to 17.8 meters for the purpose, the upper 3.5 meters of which form an apparatus for converting wood into charcoal, which is heated by a part of the gases, which are very rich under roportions. Besides wood, coke and some charcoal are used, and st is intended to have a pressure of 118 millimeters of mercury, temperature of about 500° C. In a few spiegel-iron furnaces char- ixed with English coke is used, without the addition of wood.

coal is made almost entirely from pine and fir, and every ton cubic meter) contains about 21.3 kilograms of actual carbon. nsumption of coal varies between 5 and 8 cubic meters per ton iron. In the furnaces, however, which work the very poor and erous ore from Taberg in Småland, it rises to 15.5 cubic meters. dinary consumption of coal is 5.8 to 6.6 cubic meters per ton of n, or, when reckoned by weight, 75 to 85 kilograms clear carbon kilograms pig-iron.

ore is roasted in pieces the size of one's fist, or twice as large, en crushed between rollers or in a Blake stone-crusher to the a walnut. The charges of ore are made, according to the size of nace, of 6 to 10 tons, or 0.99 to 1.65 cubic meters coal, and great used in charging, so that most of the ore lies where the most gas up, which is usually along the walls. In proportion to a cubic of coal, more of a poor ore can be charged than of a similar but ore; yet not enough of the poor ore can be added so that the nption of fuel per kilogram of pig-iron produced will not be r than for the rich ore. If the unusual proportions which the m Taberg requires are excepted, the charges give commonly 40 er cent. of pig-iron, and per cubic meter of coal 260 to 450 kilo- of ore and limestone are charged. These differences are by no occasioned by the amount of iron in the charge, but also by the difficulty of reducing the ore, so that usually considerably more ematite (blood-stone) can be charged than of the magnetite, which so easily reduced. In addition to this, the charge of ore per meter of coal can be greater, and therefore the consumption of r ton of iron less, in the larger furnaces than in the small ones; aturally in a furnace in which a higher temperature of blast is yed more ore can be added. Finally, it is to be noticed that the ization in different places is conducted with very different care- , and good coal can naturally bear more ore than loose and coal.

rding to the capacity of the furnace, the descent of the charge is apid in the smaller furnaces than in the more capacious ones. In gest furnaces, only a small change in the state of the contents of ft takes place in twenty-four hours, while in the smaller ones they ewed from two to two and a half times. The absolute change of rge, or the number of cubic meters of coal consumed in the unit , is in each case greater in the more spacious than in the smaller es. In the smallest furnaces, weekly, 30 to 64 tons, in the medium- 64 to 85, and in the largest, 85 to 130 English tons of pig-iron are ed.

The furnace-gas is generally employed for roasting the ore and heating the blast, and in such iron-works as have a lack of water-power, it serves also for heating the steam-boiler. If a Westman roasting-furnace is used, and a moderately high temperature of blast is required, then the gas is only sufficient for the two first-mentioned purposes. The whole of the gas is not available, but a part escapes through the top of the furnace, which is usually open. The gas which is used is taken out either by cylinders reaching 2.3 to 3 meters below the top, or through three or four gas-conductors, opening about a third of the height of the furnace, or 3.5 to 5 meters below the top. A few furnaces are provided with covers, but from the way in which the charging is managed, they remain open a third of the time. Only at Schisshyttan is a mouth closed according to the bell-and-hopper principle employed.

Most of the pig is destined for the "hearth-finery" according to the so-called Lancashire method, and for this purpose an iron, poor in silicon and without adhering sand, is desired; so the ordinary pig-iron is not cast in sand-molds, but in forms in which it receives the shape of broader and flatter pigs. Such iron is usually desired mottled, and for that purpose the charges are so mixed as to give about a bisilicate slag. For the production of iron destined for the manufacture of bar-iron, more basic mixtures are desired, and therefore greater quantities of limestone and manganiferous ores are employed than in the charging for merchant-iron, which can often be somewhat acid.

The pig-iron destined for the Bessemer fining is usually blown gray, nevertheless, however, with more basic charges than the above-mentioned or Lancashire pig-iron.

In the district of Dannemora an almost white iron, with small gray spots like hail-stones, which is cast in sand in the form of pigs of 4 to 6 meters in length, is desired for the Wallon fining process. The charges used in the production of this iron are the most basic of any in Sweden, with the exception of those required for spiegel iron. They approach much more nearly the singulo-silicate than the bisilicate, but no limestone is added to them, because the Dannemora ores are so rich in lime and magnesia that it happens that with the low temperature of the blast employed at Dannemora, (from unwarmed to 100° C.,) the smelting cannot be accomplished without the addition of silica.

Ordinary mottled Swedish pig for hearth-fining contains, generally, about 4 per cent. carbon, 0.1 to 0.4 per cent. silica, and 0.01 to 0.03 per cent. sulphur, and also 0.01 to 0.05 per cent., sometimes even 0.15 per cent., phosphorus. The amount of silicon in the Bessemer pig is usually about 1 per cent.; in a few places, however, it is only 0.7 per cent.

At a few furnaces, as at Schisshyttan and Finnsbo, manganiferous spiegel iron is produced. These two furnaces lie in the province of Kopparberg, and work the Svartberg ores containing knebelite. The charges are made as basic as possible, and for the production of a high temperature the charcoal is mixed with some coke. The spiegel from Schissbyttan contains occasionally 17 per cent. of manganese.

Pig-iron for ordinary castings is generally made from trisilicate charges, but this is not very important, for cast iron is imported from England and Scotland. On the other hand, at a few furnaces, a cast iron is produced superior on account of its great hardness, as at Finspong, where the cast iron is used for cannons, projectiles, car-wheels, &c., and at Ankarsrum, where the cast iron is used for projectiles and car-axles.

Finally pig-iron is also produced for malleable castings; for example at Åker and at Kihlafors.

The blast-furnace slag serves quite often as a building-material, for which purpose it is cast in iron molds, and it is very common to employ slag-bricks for the outer wall both of the cupola-furnace and the roasting-furnace; sometimes, indeed, the whole furnace-shaft is built of this material.

139. MEANS AND METHODS OF TRANSPORTATION.—In consequence of the difficulty of bringing together to one place great quantities of charcoal and ore, there have been at one place only, namely, Finspong, two furnaces till within the last year; and at most of the iron-works the material has not been sufficient to maintain the single furnaces in uninterrupted activity for the whole year. All the material must be brought to the majority of the Swedish furnaces on sleds, and, therefore, the blowing does not begin till sleighing comes. The duration of the campaign depends in great measure upon the character of the winter; for the better and longer the sleighing is, the more material can be brought. However, it has been possible at only a few places to obtain during the winter enough coal and ore to continue the campaign till sleighing begins again the next year, but it ceases usually about the beginning or middle of the following summer, and then the furnace-hands are employed about the harvest, &c. There are examples, however, of the campaign continuing uninterruptedly for six years, as at Borgvik, in Wermland.

At a few of the old iron-works, which have better communication, during the last year new furnaces have been erected beside the old ones, so that now not only at Finspong are there two furnaces, but also at Westanfors, Sandviken, Hofors, Dalkarlsbyttan, and Forsbacka. Besides, at a few others of the older works a second furnace is being built, and at some of the greater Bessemer plants, determined upon during the last year, though not yet completed, it is the plan to erect three or four blast-furnaces.

Through improved means of communication the manufacture of pig-iron is continually becoming more independent of the character of the winter; yet good and not too short sleighing will always be the chief requisite for a considerable iron-production, for the charcoal-heaps in the interior of the forest are usually attainable only when the rivers and lakes are covered with ice and the snow has made the trackless wilder-

Rolling-mills are naturally unsuitable for small iron-works, which, however, can derive advantage from them by discontinuing their old hammering-process, and instead, producing only blooms which can be worked by one rolling-mill common to several such fining-mills. In this way the rolling-mill of Smidjebacken up to the year 1871 had rolled the most, but in that year, however, Bofors had the greatest production, namely, 6,128,150 kilograms of bar and refined iron.

Besides the Lancashire method, the so-called Franche-Comté finery-process is employed, especially in small iron-works in whose neighborhood there is no rolling-mill. In the manner in which it is here conducted it is similar to the first, only the welding of the blooms occurs in the same hearth. In this process the loss is somewhat less than in the Lancashire method, in which the welding takes place in separate furnaces; on the other hand, the production is not so great, being only 3,800 to 4,300 kilograms of bar-iron weekly for each hearth. The great fault is that the consumption of coal is so great, it being about 9.7 cubic meters of charcoal per ton of bar-iron, sometimes even rising to 11.6 cubic meters or more, which will soon cause the discontinuance of this method, when improved communication shall have increased the value of charcoal in the remote districts.

In the Dannemora district the old Wallon process is employed, in which two hearths are usually worked together in such a way that the bloom produced in one is welded in the other, and then drawn under the hammer. The two hearths afford 8,500 to 10,700, sometimes even 12,700, kilograms of bar-iron weekly, with a consumption of charcoal of from 19 to 23, sometimes, however, only 15, cubic meters per ton.

In a few places, finally, other fining methods are employed, but those named are the only ones which now have any importance for Sweden. Among them all, the Lancashire method affords the most uniform and densest iron, which again depends upon the control which a well-regulated furnace has over the hands. If the welding is done in a hearth-furnace, it is much easier for the smith to draw a bar free from flaws on the outside from a bloom which is not uniform, than when the welding-furnace is used, for there the different parts of the bloom are exposed to a more uniform heating. Since uniformity and compactness are chief requisites of a good merchant-iron, naturally the Lancashire method is the most suitable fining-process for the production of such iron.

Of the Wallon iron it may be said that it is characterized by its not being uniform, or by a mixture of weak and hard, almost steel-like, iron. It is used exclusively for steel-production, and then the non-uniformity is not very injurious, while the value is really determined by the "body" caused by the properties of the ore used for the production of the iron. Indeed, it appears as if the non-uniformity of the Wallon iron was a good property in the eyes of the English steel-manufacturers, since they are opposed to changing this method. If the real cause of

is sought for, it must be found in the fact that the hard, steely
ts shorten somewhat the time required to burn this iron to steel.

he mere wages of the forgers are governed by the amount produced,
the contract is so drawn up that only one, (the master,) or more
n two, (the master and his helper, each of whom oversees his work,)
responsible for the result, and must pay fines when the loss of iron
onsumption of coal exceeds certain limits; on the other hand, how-
r, they obtain special pay for coal saved and higher wages for the so-
ed "overiron" than for the iron which they must produce from a
ain amount of pig-iron, according to contract. In addition to vari-
advantages, the master and his helper have usually 2,100 francs
ually, but they must pay their own help.

n the Lanschire method, the cost of working amounts to 10 to 13
es per ton of bloom-iron, and for the welding and drawing, to about
to 16 francs per ton of bar-iron, less for rolling, and more for hammer-
.

uring the year 1871, in the whole country, with 827 active hearths,
,791,642 kilograms of bar and refined iron were produced, and
73 workmen were employed.

41. *The pudding-process* is employed at only a few iron-works which
nufacture their own iron, namely: At Motala, Surahammar, Nyby,
nnebo, and Kallinge. The fuel used in the pudding-furnace is
ally English mineral coal, only at Surahammar and Nyby wood is
ployed.

t Motala, in a few puddling-furnaces a weak blast is used under the
te, and before it is brought into the ash-pit its temperature is raised
being conducted around the furnace-walls and under the bottom.
measure the furnaces use about 0.95 cubic meters, or 730 kilo-
ms, of mineral coal per ton of puddled-iron; on the average, the con-
ption of coal, after receiving into the coal-shed, is fully 1.2 cubic
ters, or 960 kilograms, per ton of bloom-iron, about 17 tons of
ich are produced weekly from each furnace. Surahammar uses about
ubic meters of air-dried pine wood per ton of puddled iron.

t Motala experiments are being tried with Dank's self-acting pud-
g-furnace. As the puddling has hitherto been conducted, the cost
working has been about 11 francs per ton of bloom-iron.

he welding-furnaces at Motala are exclusively heated with mineral
l, and most of them are provided with blast according to Whitten-
öm's construction. The Wittenström welding-furnace, which is used
where in some other iron-works, is in fact only a modification of the
man furnace, but not the above mentioned with the so-called "coal-
er," but that for wood. The main difference is that the fire-hearth
the last-named furnace has no grate, like the Wittenström, and that
blast, which in the Ekman furnace is introduced through the end-
l of the fire-hearth, in the other enters under the grate.

42. *Bessemer process.*—The Bessemer process has been used in
eden since its beginning, but in the year 1871 not more than 8,038,-

254 kilograms of Bessemer metal were produced, and, although this process seems very suitable for Sweden, since, on the one hand, most of the Swedish ores are well adapted for it, and, on the other, the consumption of fuel for the metal produced by this process is only about half as great as for the Lancashire iron, still the Bessemer process has not, till of late years, received a general recognition. The main cause of this lies, doubtless, in the fact that this method requires such costly apparatus, and on this account is not suitable for iron-works with a small production; in addition, the Bessemer process is not well adapted for the production of bar-iron, but requires the manufacturing or improving of the ingots produced for ready wares. The last-named circumstance should be no hinderance to the spread of the Bessemer process, for a considerable increase of the Swedish iron-industry can only be obtained by producing some other kinds of iron than bar-iron, for the demand for this in the world's market is usually very limited. In the last year Sweden has sold to foreign countries almost no other kinds of iron than bar-iron and refined steel, and it is therefore necessary, for the introduction of the Bessemer process, to create a new market, which naturally hinders the spread of this process. All the large iron-works completed lately, lying on the projected railways, are intended for the Bessemer manufacture, and, in addition, in the year 1872, four Bessemer works, Forsbacka, Abäckshyttan, Långshyttan, and Iggesund, have been completed, and two others, Långbanshyttan and Ulfshyttan, nearly so, and, finally, many iron-works which have hitherto used the Lancashire method are erecting Bessemer works.

In the year 1871 there were seven Bessemer works in operation, but the production at three of them, which have small upright furnaces, was very slight, from all of them not amounting to more than 397,740 kilograms. The rest, or 7,649,514 kilograms, was produced at Sandviken, Westanfors, Svartnäs, and Bäcka, where the English movable furnaces are used. All the Bessemer works erected during the previous year have movable furnaces, and it is very improbable that hereafter any stationary Bessemer furnaces will be built.

In all the Swedish Bessemer works, as hitherto conducted, the pig-iron is taken directly from the blast-furnace without remelting. In the movable furnaces (converters) charges of 2,300 to 3,900 kilograms are employed. The converters have six to seven brick tuyeres, each of which has six to seven holes, with a diameter of 11 to 18 millimeters. The pressure of blast is usually between 600 and 900 millimeters of mercury, and the whole process is finished generally in 4 to 10 minutes. With the exception of Sandvicken, where steam is partly used, all the larger Bessemer works use water-power entirely. The blowing-engines, both at the above-named works and those lately erected, are from 350 to over 500 horse-power.

At some Bessemer works 1 or 2 per cent. of spiegel iron is added toward the close of the process; in others, however, which work more manganiferous ores, no addition of spiegel is necessary, since as soft an iron as desired may be produced in them without danger of redshortness.

Of the weight of pig-iron used, 85 to 89 per cent. Bessemer ingots is generally obtained, and only a few per cent. of waste.

143. *Martin steel, cement-steel, &c.*—Since the year 1868, at Munkfors, cast steel has been produced in a Siemens regenerating-furnace with a Lundin condenser, according to the method of Martin. Also, at Lesjöfors, such steel has begun to be produced, and experiments on a smaller scale have been commenced at some other works.

The furnaces are small, holding only 800 to 1,300 kilograms. For fuel air-dried wood is used; 6 to 7.4 cubic meters per ton of melted steel or iron. The most noticeable fact is that in this way uniformly-soft iron can be produced successfully, which is rolled into nail-iron or wire.

At Wiksnanshyttan cast steel is produced by the Uchatius method, from granulated pig-iron mixed with powder of rich ore and a little charcoal. The fusing takes place in graphite crucibles in ordinary English furnaces heated with coke. The steel produced in this way is suitable for such purposes as require great compactness with considerable hardness, as for dies, hammers, &c.

Hitherto cement-steel has been pretty generally produced, which is drawn before it goes into the market under various names. At Surahammar and Motala puddled steel is also produced, and at Graningo some raw steel is made on the hearth. In addition, cast-steel works have been erected at Österby for melting in crucibles in a Siemens-Lundin furnace, using wood as fuel.

The iron and steel manufacture is not yet great enough to satisfy the demands of the country itself; it is hoped, however, that in a few years quite different relations in this respect will come about, for all the greater Bessemer works mentioned below are intended for the manufacture of rails and other railroad material, together with sheet-iron.

144. ROLLING-MILLS.—The foremost of the rolling-mills, hitherto in operation, for sheet-iron is Motala, and next Surahammar and Kloster are the greatest, although at the last mentioned only thin plate, like wire-plate, &c., is made. At Surahammar puddled iron is used exclusively for the manufacture of plate; at Motala the Bessemer iron from this and other iron-works is used. At Kloster the Lancashire iron was formerly employed, but they have in view now the plan of using the Bessemer iron from Långshyttan, which belongs to the same company.

Iron rails of the ordinary dimensions at present can be produced at only two works, namely, Motala and Smedjebacken. At the first-named works, during the year 1871 there were rolled out—

	Kilograms.
Bessemer-steel rails	1,190,200
Puddled-iron rails	76,400
Puddled-iron rails with heads of Bessemer steel	870,900
Total	2,137,500

At Smedjebacken, in the same year, 1,083,792 kilograms of rails were rolled, 119,084 kilograms of which were from the Bessemer steel from from Bäcka, and the rest from Lancashire iron.

Car-wheels of wrought iron are manufactured only at Surahammar, where tires of puddled steel are also made; Sandviken is the only place, however, where tires have been made in large quantity, and from Bessemer steel hitherto.

At Surahammar car-axles of puddled steel are made, and at a few machine-shops machine-axles from iron-waste are made; but the chief places for the production of large axles at present are Motala, where they can be obtained either of Bessemer or puddled steel as desired; and also Fagersta and Sandviken, which make them only of Bessemer steel.

Nails are manufactured at many works and in very different ways, but this manufacture is carried on to the greatest extent in the provinces of Blekinge and Ostgothland, where they are made mostly by cutting out of plate, and next in Wermland, where they are produced mainly by machines from wire. Besides this, many nails are manufactured by hand.

A part of the Bessemer metal of Westanfors is worked at Fagersta, which belongs to the same proprietor, to gun-barrels, saws, and springs; but Eskilstuna is the chief place for the manufacture of small articles of iron and steel, like locks, tools, knives, arms, &c.

Wire is drawn at many works, as Kolsva, Bofors, Degerfors, Gunnebo, Lesjöfors, and Munkfors; but Lesjöfors is the main place for wire-drawing, and part of the wire is employed on the spot for the manufacture of rope and nails.

145. *Table showing the amount of ore obtained and the manufacture of pig and wrought iron, steel and manufactured wares, in the years 1860, 1865, 1870, and 1871, as far as it has been announced by the Royal Commercial College.*

	1860.	1865.	1870.	1871.
	Kilogs.	*Kilogs.*	*Kilogs.*	*Kilogs.*
Mine-ores	395, 145, 000	496, 824, 000	617, 037, 000	647, 119, 000
Bog-ores	22, 228, 000	20, 312, 000	13, 756, 000	15, 769, 000
Total iron-ores	417, 373, 000	517, 136, 000	630, 793, 000	662, 888, 000
Pig	179, 912, 000	221, 389, 000	293, 278, 000	293, 118, 000
Cast-iron wares produced directly at the blast-furnace.	5, 237, 000	5, 350, 000	7, 218, 000	5, 800, 000
Total cast iron	185, 149, 000	226, 739, 000	300, 496, 000	298, 918, 000
Bar, band, nail, wire iron, &c	136, 932, 000	148, 512, 000	193, 908, 000	187, 792, 000
Bessemer metal	24, 239, 000	4, 425, 000	6, 637, 000	*8, 038, 000
Other steel		2, 988, 000	5, 550, 000	4, 013, 000
Plate		5, 986, 000	5, 735, 000	6, 564, 000
Nails		5, 957, 000	4, 787, 000	6, 138, 000
Implements and sundries		7, 852, 000	10, 304, 000	14, 362, 000

* This number does not correspond with that of the Commercial College, for the production of Westanfors, Svartnäs, and Bacha, for 1871, is not included in the latter.

	1860.		1865.		1870.		1871.	
	Export.	Import.	Export.	Import.	Export.	Import.	Export.	Import.
	Kilogs.	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*
Ore	2, 254, 000	....	7, 745, 000	....	13, 126, 000	....	11, 902, 000	....
Pigs	12, 725, 000	2, 085, 000	16, 018, 000	4, 877, 000	39, 940, 000	5, 147, 000	41, 085, 000	7, 233, 000
Pigs in scrap	....	....	326, 000	....	464, 000	....	255, 000	....
Cast iron	1, 054, 000	596, 000	287, 000	45, 000	692, 000	46, 000	626, 000	221, 000
Blooms	1, 821, 000	....	3, 936, 000	....	7, 907, 000	....	10, 423, 000	....
Bar-iron	97, 657, 000	276, 000	89, 553, 000	1, 171, 000	135, 131, 000	974, 000	143, 335, 000	1, 364, 000
Band, nail iron, &c	1, 303, 000	418, 000	2, 423, 000	528, 000	18, 373, 000	836, 000	17, 906, 000	1, 227, 000
Rails	....	398, 000	....	21, 643, 000	359, 000	4, 766, 000	1, 071, 000	10, 050, 000
Plate	632, 000	122, 000	680, 000	356, 000	670, 000	1, 419, 000	784, 000	1, 720, 000
Nails and small articles	1, 227, 000	63, 000	1, 401, 000	174, 000	898, 000	182, 000	1, 106, 000	377, 000
Scrap-iron	780, 000	1, 000	1, 455, 000	30, 000	4, 118, 000	248, 000	4, 803, 000	323, 000
Steel	7, 244, 000	93, 000	4, 697, 000	100, 000	3, 251, 000	172, 000	5, 349, 000	310, 000
Steel-work	....	5, 784	....	4, 551	....	198, 020	....	16, 161
Iron and steel wire	27, 049	28, 750	44, 061	197, 041	59, 032	65, 454	95, 990	60, 775
Tinned plate	....	196, 786	....	312, 043	....	526, 819	1, 276	693, 452
	Francs.	*Francs.*	*Francs.*	*Francs.*	*Francs.*	*Francs.*	*Francs.*	*Francs.*
Implements, railroad materials, and machines	53, 466	3, 069, 049	91, 045	3, 989, 932	1, 177, 648	4, 156, 094	552, 679	5, 217, 658

Table showing the ore obtained and the iron manufactured, as well as the number of hands, in the different provinces during the year 1871, as published by the Royal Commercial College.

Province.	Ore obtained.		Hands employed in obtaining the ore.				Pig-iron.					
										Pig-iron produced in the form of—		
	Mine-ores.	Bog-ores.	Steady hands.	Occasional hands.	Women and children.	Total number of persons.	No. of blast-furnaces out of blast.	No. of blast-furnaces in blast.	Entire time of blast.	Pigs.	Cast iron.	Total pig-iron.
	Kilogs.	*Kilogs.*							*Days.*	*Kilogs.*	*Kilogs.*	*Kilogs.*
Norrbotten	21,265	.....	.....	3	.....	3	6	.....	.....	.....	.....	.....
Westerbotten	.....	.....	.....	.....	.....	.....	1	3	344½	2,384,097	221,879	2,606,876
West-Norrland	928,855	.....	6	4	1	11	1	4	480¾	3,315,724	80,637	3,396,361
Jemtland	15,736	.....	6	.....	.....	6	1	1	33⅙	65,326	.....	65,326
Gefleborg	22,444,697	.....	197	10	.....	207	8	19	3,102⅛	31,166,920	241,698	31,408,618
Upsala	33,132,273	.....	409	19	15	443	9	2	333¼	2,988,753	83,274	3,072,027
Stockholm	29,367,688	.....	271	75	45	391	2	3	391⅝	3,581,324	89,185	3,670,509
Kopparberg	178,046,656	.....	750	73	116	939	19	45	7,876	67,736,680	489,903	68,226,583
Westmanland	92,225,667	.....	375	54	.....	429	10	16	2,810	23,054,790	340,708	23,395,498
Örebro	135,690,051	.....	1,054	165	38	1,257	16	54	11,046½	86,249,181	2,063,895	88,315,076
Skaraborg	.....	127,590	.....	.....	.....	.....	.....	1	259	1,680,530	48,697	1,729,227
Wermland	121,252,392	.....	855	.....	85	940	6	26	5,442¾	45,395,076	699,014	46,094,090
Elfsborg	.....	.....	.....	.....	.....	.....	.....	1	68½	413,987	7,188	421,175
Gothenburg n. Bohus	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Södermanland	19,231,386	.....	172	11	11	194	2	6	1,224¼	5,744,867	489,010	6,233,877
Ostgothland	4,450,169	.....	38	.....	.....	38	.....	4	1,030	8,355,614	87,229	8,442,843
Calmar	382,770	555,527	4	10	1	15	5	6	759½	4,110,269	75,491	4,185,760
Jönköping	9,910,128	8,911,864	51	40	.....	91	2	12	1,610⅓	5,097,901	420,324	5,518,225
Kronoberg	19,266	6,174,463	3	12	.....	15	4	4	658	1,775,032	360,357	2,135,389
Halland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Blekinge	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Christianstad	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Malmöhus	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	647,118,999	15,769,444	4,191	476	312	4,979	92	207	37,471	293,116,971	5,800,480	298,917,460

Province.	Bar-iron.		Steel.			Manufactured wrought iron.				works.			
			Bessemer steel.		Other steel, mainly shear-steel								
	Number of hearths in operation.	Bar-iron produced.	Number of works.	Product.	Product.	Plate.	Nails.	Rails.	Implements and sundries.	In the blast-furnaces.	In bar-iron works.	In manufacturing and casting.	Total number of persons.
		Kilogs.		*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*	*Kilogs.*				
Norrbotten	5	236, 807	..	....	....	....	29, 686	....	35, 470	....	29	15	44
Westerbotten	12	2, 387, 166	..	....	....	....	24, 242	....	89, 526	58	70	37	165
West-Norrland	37	4, 825, 752	..	....	6, 082	....	110, 238	....	442, 057	65	177	176	418
Jemtland	2	42, 190	.	....	....	....	2, 297	....	7, 060	4	7	9	20
Gefleborg	114	24, 816, 808		4, 135, 192	503, 470	....	122, 019	....	1, 927, 715	384	643	370	1, 397
Upsala	31	6, 294, 657		184, 282	80, 297	....	....	....	107, 558	56	222	21	299
Stockholm	14	2, 877, 878	..	....	....	....	33, 471	....	15, 949	75	122	687	874
Kopparberg	100	22, 999, 586		*1, 254, 975	186, 196	911, 758	280, 060	1, 083, 792	358, 400	844	786	475	2, 105
Westmanland	78	24, 541, 894		*2, 424, 210	1, 540, 054	1, 189, 734	45, 677	....	407, 097	329	649	698	1, 676
Örebro	114	32, 818, 445		39, 595	578, 876	....	375, 370	....	1, 332, 848	923	1, 095	192	2, 210
Skaraborg	12	1, 590, 750	..	....	....	....	97, 181	....	163, 868	18	60	132	210
Wermland	141	34, 635, 496	..	....	684, 265	....	1, 004, 729	....	1, 170, 043	505	1, 118	357	1, 980
Elfsborg	18	3, 932, 834	..	....	489, 052	....	194, 872	....	189, 811	21	133	116	270
Gothenburg u. B[illegible]	1	22, 626	.	....	....	....	17, 182	....	312, 383	....	....	504	504
Södermanland	13	2, 027, 490	..	....	....	340, 240	226, 009	....	90, 121	105	76	230	411
Östgothland	69	10, 569, 258	..	....	115, 426	3, 633, 848	1, 172, 169	2, 137, 500	1, 024, 930	91	418	581	1, 090
Calmar	30	5, 504, 233	..	....	3, 530	....	505, 937	....	446, 395	104	249	229	582
Jönköping	22	2, 154, 357	..	....	....	....	146, 686	....	400, 165	178	149	122	449
Kronoberg	11	1, 022, 932	..	....	....	....	175, 649	....	159, 743	52	70	129	251
Halland	....	....	..	....	....	....	....	....	5, 104	....	....	2	2
Blekinge	3	4, 491, 083	..	....	....	488, 287	1, 504, 541	....	15, 353	....	....	215	215
Christianstad	....	....	..	....	....	....	....	....	367, 332	....	....	75	75
Malmöhus	....	....	..	....	....	....	....	....	988, 525	....	....	223	223
Total	827	187, 791, 642	7	*8, 038, 254	4, 187, 248	6, 563, 867	6, 138, 015	3, 221, 292	10, 057, 453	3, 812	6, 073	5, 595	15, 480

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* These numbers do not correspond with those of the Commercial College, for the production of Westanfors, Svartnäs, and Bäcka is omitted in the latter.

146. *Locality of greatest production.*—It is evident from the foregoing table that the greatest production of ore is in the province of Kopparberg, and then follow Örebro, Wermland, and Westmanland.

The largest production of pig-iron is in Örebro. Among the provinces rich in ore, Westmanland has the smallest production of pig-iron, not only absolutely but relatively to its production of ore. This is owing to the fact that a considerable part of the ore obtained from its largest mine, Norberg, is taken to other provinces, as Gefleborg, Kopparberg, Ostgothland, Calmar, West-Norrland, and Westerbotten, while the inhabitants of Westmanland use a great part of their abundance of coal for hearth-firing the pig-iron obtained from the provinces Kopparberg and Örebro. Also, in the provinces of Wermland and Kopparberg, the manufacture of pig-iron is small in proportion to the amount of ore obtained, since, as has been mentioned, a part of the ore of these provinces is taken to the blast-furnaces in the provinces of Örebro and of Kopparberg, and many other furnaces. By far the greatest part of the ore obtained in the provinces of Upsala and Stockholm is taken to other provinces, as Norrland, and to Ostgothland and Calmar. The last-named provinces, which are poor in ore, fetch their ore both from the Norberg, in the province of Westmanland, which has been already mentioned, and also from the region of Nora, in the province Örebro, from Grängesberg, and many other places in the province of Kopparberg.

Although the manufacture of bar-iron is greatest in the province of Örebro, yet it does not correspond to the production of pig-iron; for a great part of the pig-iron is sold as such partly to other provinces, partly to foreign countries. The same holds good, though in a less degree, of the province of Kopparberg, whence pig-iron, for the purpose of conversion into wrought iron, is imported into the provinces of Ostgothland, Westmanland, West-Norrland, Calmar, &c. The production of bar-iron is greatest in the provinces of Wermland and Örebro, and next following them Gefleborg, Westmanland, and Kopparberg.

As has been shown above, considerable interchange of ore and pig-iron takes place between the different provinces. This is partially accounted for by the fact that many works, in consequence of lack of fuel and other circumstances, can be carried on more advantageously in other places than in the neighborhood of the mine; partly also because some mines lie so near the boundary of the province that the transportation of the ore from one province to another is a small matter. On the other hand, the transportation would be wholly unnecessary if many works had not been in the beginning located disadvantageously, and, therefore, many alterations for the better may be expected when those now building, and possibly also other means of communication, shall have been completed.

147. CHEMICAL COMPOSITION OF SWEDISH ORES.—The following tables contain the results of analyses of the principal iron-ores of Sweden; the locality, name of the chemist, and a reference to the original publication:

Analyses of Swedish iron-ores.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Occurring in the ore.					
					Oxide of iron.	Protoxide of manganese.	Copper, cobalt, zinc, &c.	Phosphorus.	Sulphur.	Titanic acid or oxide.
IN THE PROVINCE OF NORRBOTTEN.										
Torneå Lappmarken, parish Juckasjervi.										
Kurunavara	S.	Raw	1872	C. A. Wrang	*88. 4 per cent. Fe^3O^4	*0. 28		1. 62	(0. 04)	
Luossavara	G.	Raw	1861	L. Rinman	*98. 5 " "	†0. 016		0. 107		0. 67 p. c. Ti O^2
Luleå Lappmarken, parish Gellivara.										
Gellivara, Herzog von Upland	G.	Raw	1862	L. Rinman	92. 1 per cent. Fe^3O^4			0. 742		
Gellivara, Törefors und Gyljen	G.	Raw	1862	do	94. 0 " "			0. 020		
Gellivara, Tingvalls Hügel	G.	Raw	1862	do	90. 7 " "			0. 512		
Gellivara, Robsahm	G.	Raw	1862	do	87. 8 " "			0. 038		
Gellivara, Wälkomman	G.	Raw	1862	do	88. 5 per cent. $\left\{\begin{matrix}Fe^3O^4\\Fe^2O^3\end{matrix}\right\}$			0. 394		
Gellivara, Friederike's Schürfen	G.	Raw	1862	do	92. 3 per cent. Fe^2O^3	Trace		0. 019		
Routivara	G.	Raw	1862	do	74. 9 per cent. Fe^3O^4	0. 5		0. 004	Trace	9. 20 p. c. Ti^2O^3
Parish Unter-Luleå.										
Hindersö	G.	Raw	1872	O. Baer	65. 9 per cent. Fe^3O^4	0. 14		(0. 008)	(0. 04)	
IN THE PROVINCE OF WEST-NORRLAND.										
Parish Nätra.										
Ulfö	G.	Raw	1872	A. Tamm	$\left\{\begin{matrix}\text{30. 2 per cent. } Fe\,O\\ \text{15. 3 per cent. } Fe^2O^3\end{matrix}\right\}$	0. 69	0. 03 per ct. Cu.	0. 03	0. 01	9. 51 p. c. Ti O^2
IN THE PROVINCE OF GEFLEBORG.										
Parish Voxna.										
Gymås, Konst-Grube	G.	Roasted	1859	D. A. Kruhs	*48. 3 per cent. Fe^3O^4	†0. 31		0. 061	(0. 1)	

Analyses of Swedish iron-ores—Continued.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Occurring in the ore.					
					Oxide of iron.	Protoxide of manganese.	Copper, cobalt, zinc, &c.	Phosphorus.	Sulphur.	Titanic acid or oxide.
PROVINCE OF GEFLEBORG—Continued.										
Parish Thorsåker.										
Nyäng, Alte Öster-Grube	G.	Raw	1868	A. Burén	*68.0 per cent. $Fe^3 O^4$	10.45		(0.004)	(0.05)	
Nyäng, Neue Öster-Grube	G.	Raw	1868	G. Svedelius	79.4 " "	0.11				
Nyäng, Wester-Grube	G.	Raw	1868	do	70.5 " "	0.05				
Nyäng, Nore	G.	Raw	1868	do	49.5 " "	Trace		0.015		
Erik Ers		Raw	1863	L. Rinman	77.8 " "	3.60		0.008	0.3	
Penning	G.	Raw	1860	G. L. Wettordal	*60.3 " "	†14.6		0.012	(0.04)	
Do	G.	Raw	1868	G. Svedelius	71.1 " "	11.62		0.008	0.02	
Malmberg	G.	Raw	1868	do	51.1 " "	Trace		0.008	0.009	
Gösk, Erz No. 3	G.	Raw	1868	A. Tamm	28.7 " "	0.54		0.013	Trace	
Nyberg	G.	Raw	1868	G. Svedelius	71.4 " "	Trace		0.022	0.053	
Masmästaren	G.	Roasted	1872	J. E. Eklund	67.7 " "	1.02				
Fogelmossen	G.	Raw	1872	J. E. Eklund	38.4 " "	2.98				
Hedberg	G.	Raw	1868	G. Svedelius	79.6 " "	0.14		0.015	Trace	
Afze		Raw	1862	H. Limnelius	26.0 " "	5.59		0.010	(0.06)	
Afze, Erz No. 1	G.	Raw	1868	G. Svedelius	58.2 " "	3.14		0.008	0.94	
IN THE PROVINCE OF UPSALA.										
Parishes Films and Dannemora.										
Dannemora, Harnäs Hauptgattirung, 1866.	G.	Roasted	1866	C. A. Löthner	*74.9 per cent. $Fe^3 O^4$	†11.53		(0.006)	(0.04)	
Dannemora, Nördl. Feld, (die bei Harnäs gebrauchten Erze von hier.)	G.	Roasted	1866	C. A. F. Reuterskiöld.	*74.7 " "	†11.52		(0.01)	(0.03)	
Dannemora, Nördl. Feld, Nördl. Kunga-Grube.	G.	Raw	1865	B. Fernqvist	70.7 " "	2.00		0.0026	0.08	
Dannemora, Zwischenfeld, De Geer, Jord-Grube.	G.	Raw	1865	do	77.4 " "	1.60		0.0098	0.033	

Parish Alunda.										
Hammarin..............................	G.	Roasted	1872	O. Alströmer......	*73. 6 per cent. $Fe^3 O^4$	†1. 75	....	(0. 02)	(0. 08)	....
Parish Lena.										
Sahlsta	G.	Raw	1863	L. Rinman	80. 2 per cent. $Fe^3 O^4$	0. 15	....	0. 015	0. 05	....
Lenaberg, Zwischengrube..............	S.	Raw	1872	J. E. Eklund......	*91. 9 " "	†0. 54	....	(0. 012)	....	....
Brunna..............................	......	Raw	1872	...do	*81. 7 " "	†0. 20	....	(0. 0075)	....	....
IN THE PROVINCE OF STOCKHOLM.										
Parish Wahlö.										
Vigelsbo, Stockenströms-Grube........	G.	Raw	1870	J. W. Lewert......	*68. 8 per cent. $Fe^3 O^4$	†0. 30	....	(0. 01)	(0. 04)	....
Vigelsbo, Myr-Grube..................	G.	Raw	1870	E. S. Steffansson...	*67. 1 " "	†0. 23	....	....	(0. 03)	....
Parish Börstil.										
Sand..............................	G.	Raw	1868	A. V. Blomberg ...	*74. 2 per cent. $Fe^3 O^4$	†0. 49	....	(0. 03)	(0. 02)	....
Skedika, Nördliche	G.	Roasted	1866	T. Casselli	75. 9 " "	0. 36	....	0. 046	(0. 03)	....
Parish Öregrund or Gräsö.										
Sladdarö..............................	G.	Raw ...	1863	L. Rinman	79. 0 per cent. $Fe^3 O^4$	0. 25	....	0. 013	0. 045	....
Parish Häfverö.										
Herräng, Lapp-Grube..................	G.	Raw	1867	G. Svedelius	73. 3 per cent. $Fe^3 O^4$	0. 37	....	0. 010	0. 021	....
Parish Singö.										
Singö, Boudd-Grube..................	G.	Raw	1871	A. Tamm	*74. 0 per cent. $Fe^3 O^4$	†0. 14	....	(0. 005)	(0. 2)	....
Parish Österhanninge.										
Utö..............................	G.	Roasted	1862	J. A. Kullström ...	*53. 6 per cent. $Fe^2 O^3$	†0. 53	(0. 06 per ct. Cu.)	(0. 165)	(0. 04)	....
IN THE PROVINCE OF KOPPARBERG.										
Parish Leksand.										
Sörskog, Erz No. 2	......	Raw	1859	C. Wahlund.......	*57. 2 per cent. $Fe^3 O^4$....	†1. 23	....	0. 005	(0. 05)	....
Parish Åhl.										
Sommarberg..........................	G.	Roasted.	1858	G. Hjort af Ornäs..	*48. 7 per cent. $Fe^3 O^4$....	†0. 93	....	....	....	....
Blackberg	G.	Roasted.	1858	F. Lindebäck	*58. 2 " "	†0. 35	....	(0. 042)	....	....

Analyses of Swedish iron-ores—Continued.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Occurring in the ore.					
					Oxide of iron.	Protoxide of manganese.	Copper, cobalt, zinc, &c.	Phosphorus.	Sulphur.	Titanic acid or oxide.
PROVINCE OF KOPPARBERG—Continued.										
Parish Svärdsjö.										
Vinkärn, Svartnäs Mischung	G.	Roaste	1871	G. Réhn	{ 48.2 per cent. $Fe^2 O^3$ } { 15.7 per cent. Fe O }	0.15	....	....	....	....
Vinkärn, Gammel-Grube	G.	Raw	1864	A. Andersson	*59.5 per cent. $Fe^3 O^4$	†0.12	....	(0.03)	(0.01)	....
Vinkärn, Öster Grube	G.	Raw	1868	T. Annerstedt	*64.0 " "	†0.21	....	....	....	....
Parish Kopparberg.										
Harmsarf	G.	Roasted	1860	A. Carlsson	*72.7 per cent. $Fe^3 O^4$	†0.27	....	0.026	....	....
Parish Stora Tuna.										
Hästberg	G.	Roasted	1856	C. A. Jacobsson	*69.0 per cent. $Fe^3 O^4$	†0.4	....	0.02	(0.04)	....
Do	G.	Roasted	1872	C. A. Wrang	69.0 " "	0.04	....	0.021	....	....
Romme, Örn-Grube	G.	Roasted	1866	J. Bratt	*77.6 " "	†0.48	(0.07 per ct. Cn.)	(0.017)	(0.03)	....
Parish Säter.										
Stora Bispberg, Prima Erz	G.	Roasted	1871	J. Ekman	{ 68.8 per cent. $Fe^2 O^3$ } { 21.7 per cent. Fe O }	0.16	(0.01)	0.008	....	....
Parish Husby.										
Rellingsberg	G.	Roasted	1866	J. Wiborgh	*84.2 per cent. $Fe^3 O^4$	†0.41	....	(0.008)	(0.02)	....
Rellingsberg, Prima Erz	G.	Raw	1871	W. Lagergren	88.7 " "	0.45	....	(0.007)	(0.03)	....
Parish Garpenberg.										
Långvik	G.	Roasted	1861	J. F. Lundberg	*60.4 per cent. $Fe^3 O^4$	†8.01	Traces of Cu	(0.02)	(0.02)	....
Holm	G.	Roasted	1861	do	*64.9 " "	†7.25	{ 0.005 p. c. Cu. } { 0.13 p. c. Pb }	(0.02)	(0.05)	....

Parish By.										
Vestansjö, Secunda Ers	S.	Raw	1859	W. Tham	*55.3 per cent. Fe^3O^4	†0.30		Trace	(0.01)	
Parish Folkärna.										
Knutsbo	G.	Roasted.	1861	J. F. Lundberg	*64.0 per cent. Fe^2O^3	†1.36		(0.02)	(0.03)	
Parish Grangärdes.										
Hästberg oder Fäboback	G.	Raw	1872	A. Tamm	23.7 per cent. Fe^2O^3 15.1 per cent. FeO	6.79		(0.06)	(0.034)	
Grängesberg:										
Grängesbergsfeld, nördliches, Enkulle-Grube.	G.	Raw	1861	L. Rinman	82.5 per cent. Fe^2O^3	Trace		0.101	(0.02)	
Grängesbergsfeld, südliches, Bredsjöbrottet.	G.	Raw	1861	do	89.9 per cent. Fe^3O^4			0.502	(0.04)	
Grängesbergsfeld, südliches, Galthufvud-Grube.	G.	Raw	1861	do	85.5 per cent. Fe^2O^3			0.118	(0.04)	
Ormbergsfeld, östl., Kittel-Grube	G.	Raw	1861	do	81.9 " "			0.129	(0.03)	
Ormbergsfeld, östl., Björnhytte-u. Badstu Grube.			1865	C. H. Lundström	80.6 " "	0.52		0.121	(0.045)	
Do	G.	Raw	1872	A. Tamm	68.0 per cent. Fe^2O^3 12.9 per cent. FeO	Trace		(0.119)	(0.04)	
Ormbergsfeld, westliches, Tviste Granlund.			1865	C. H. Lundström	81.0 per cent. Fe^2O^3	0.11		0.088	(0.027)	
Ormbergsfeld, westliches, Abrahams-Grube.	G.	Raw	1861	L. Rinman	84.1 per cent. Fe^3O^4			1.27	(0.02)	
Ormbergsfeld, westliches, Kleine Pick-Grube.	G.	Raw	1861	do	96.5 per cent. Fe^2O^3			0.065	(0.03)	
Bäckberg, Bultar-Grube	G.	Raw	1864	O. H. Sillén	*60.9 per cent. Fe^3O^4	†0.15		(0.12)	(0.03)	
Parish Ludvika.										
Finnäs, Byberg-Grube	G.	Raw	1867	G. Svedelius	68.9 per cent. Fe^3O^4	0.51		0.031	Trace	
Fredmundsberg, Compagnie-Grube	G.	Raw	1871	A. Tamm	52.7 per cent. Fe^2O^3 26.3 per cent. FeO	0.10		1.175	Trace	
Fredmundsberg, Tägt-Grube	S.	Raw	1863	J. F. Lundberg	*69.3 per cent. Fe^3O^4	†0.44		(0.05)	(0.04)	
Iviken, Lång-Grube	G.	Roasted	1861	J. N. Björlingsson	*64.7 per cent. Fe^2O^3	†0.87		(0.09)	(0.03)	
Iviken, Lejon-Grube	G.	Raw	1860	C. H. Lundström	73.5 per cent. Fe^3O^4	0.46		0.034	0.090	
Iviken, Femman-Grube	G.	Roasted	1860	W. Tham	48.8 " "	0.15				
Iviken, Ko-Grube	G.	Raw	1867	G. Svedelius	77.0 " "	Trace		0.045	0.007	
Do	G.	Raw	1872	A. Tamm	53.4 per cent. Fe^2O^3 14.5 per cent. FeO	0.56		(0.065)		
Gräsberg, Stor-Grube	G.	Raw	1867	G. Svedelius	65.5 per cent. Fe^3O^4	0.23		(0.022)	0.001	
Gräsberg, Herkules-Grube	G.	Raw	1867	do	74.8 per cent. Fe^2O^3	0.19		(0.030)	0.016	
Gräsberg, Kapitän-Grube	G.	Roasted	1859	C. W. Rinman	*61.2 per cent. Fe^2O^3 Fe^3O^4	†0.30		(0.043)	(0.02)	
Gräsberg, Sultin-Grube	G.	Raw	1867	G. Svedelius	66.5 per cent. Fe^2O^3	0.63		(0.033)	Trace	

Analyses of Swedish iron-ores—Continued.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Oxide of iron.	Occurring in the ore: Protoxide of manganese.	Occurring in the ore: Copper, [illegible]	Occurring in the ore: Phosphorus.	Occurring in the ore: Sulphur.	Occurring in the ore: [illegible]
PROVINCE OF KOPPARBERG—Continued.										
Parish Ludvika.										
Håksberg, nordlicher, Mild Grube	G.	Raw ...	1871	A. Tamm	*70.0 per cent. { Fe^2O^3 Fe^3O^4 }	10.01	....	(0.201)	(0.02)	
Håksberg nordlicher, [illegible]	G.	Raw ...	1871	...do	*70.4 per cent. Fe^3O^4	10.03	....	(0.196)	(0.01)	.. .. .
Håksberg, südlicher, [illegible] Grube	G.	Raw ...	1871	...do	{ 67.0 per cent. Fe^2O^3.. 11.3 per cent. FeO .. }	0.08	....	(0.063)	....	..... .
Parish [illegible].										
[illegible] Grube.	G.	Raw	1861	L. Rinman	64.2 per cent. Fe^3O^4		....	0.0096	0.058	....
[illegible] Grube	G	Roasted	1859	G. Hjort af Ornäs	*58.2 " " ...	10.62	....	0.017	(0.01)	....
[illegible] Grube	G	..	1860	J. G. Wiborgh ...	60.8 " " ...	19.98	....	....	....	....
[illegible]			..	....	56.9 " " ...	18.42	....	0.010	1.34	....
[illegible]	G	Raw	1872	A. Tamm	{ 27.3 per cent. FeO .. 22.6 per cent. Fe^2O^3 .. }	13.03	....	(0.021)	....	....
[illegible] nordlicher, [illegible] Grube	G	Raw	1867	G. Svedelius	60.8 per cent. Fe^3O^4	0.33	....	0.017	Trace ..	....
Parish [illegible].										
[illegible]	G	Raw	1865	T. [illegible]	*53.1 per cent. Fe^3O^4	13.62	....	(0.014)	(0.03)	....
IN THE PROVINCE OF WESTMANLAND.										
Parish Norberg.										
Norberg:										
[illegible]feld, [illegible]	G	Raw .	1858	L. Rinman .. .	70.9 per cent. Fe^3O^4 ..	.....	....	0.028	0.005	....
[illegible]feld, [illegible]	G.	Raw .	1872	E. Brusewitz	71.0 " " ..	0.15	....	0.032	....	....
[illegible]feld, [illegible]	G	Raw	1864	R. Fornqvist	71.3 " " .	0.15	....	0.003	0.006	....
[illegible]feld, [illegible] Grube		.....	1863	P. H. Fagerholm.	*77.6 " "	10.31	.. ..	0.05	0.03	....
[illegible]feld, [illegible] Grube	G.	Raw	1866	R. Fornqvist.....	64.0 per cent. Fe^3O^4 ..	0.10	....	0.014	0.003	....
[illegible]feld, südliche [illegible] Grube	S.	Raw . .	1872	E. Brusewitz ..	24.4 per cent Fe^2O^3	31.50	....	0.041	....	....
[illegible]feld, alten, grossen [illegible] Grube	G.	Raw	1866	R. Fornqvist	60.0 " " . .	0.05	. ...	0.031	0.021	... .

Parish Grythytte.										
Högborn, Stoll-Grube	G.	Raw	1868	L. Rinman	80.3 per cent. Fe^3 O^4	0.10		Trace	0.01	
Parish Jernboas.										
Rastolf	G.	Raw	1872	B. Fernqvist	62.5 per cent. Fe^3 O^4	0.12		0.001	0.011	
Lakäng	G.	Raw	1866	do	79.0 " "	0.06		0.003	0.01	
Parish Nora.										
Striberg, Åsboberg	G.	Raw	1866	C. H. Lundström	86.7 per cent. Fe^2 O^3	0.05		0.019	0.05	
Striberg, Svartberg	G.	Raw	1866	do	79.7 per cent. Fe^3 O^4	0.45		0.007	0.045	
Striberg, Mossaberg	G.	Raw	1855	L. Rinman	71.5 per cent. Fe^2 O^3			0.052		
Striberg, Smedjo-Grube	G.	Raw	1860	C. H. Lundström	71.4 " "	0.14		0.016	0.04	
Striberg, Stor-Grube	G.	Raw	1866	do	75.1 " "	0.19		0.023	0.05	
Striberg. Komminister-Grube	G.	Raw	1865	do	76.3 " "	0.07		0.013	0.66	
Striberg, obere Kärr-Grube	G.	Raw	1865	do	76.5 " "	0.14		0.020	0.035	
Lerberg, Djup-Grube	G.	Raw	1862	L. Rinman	83.9 per cent. Fe^3 O^4	0.15		0.002	Trace	
Pershyttan, Lock-Grube	G.	Raw	1866	B. Fernqvist	78.9 " "	0.16		0.018	0.007	
Do	G.	Raw	1868	do	75.5 per cent. Fe^2 O^3	0.03		0.02	0.025	
Pershyttan, Kittel-Grube	G.	Raw	1866	do	74.6 " "	0.15		0.025	Trace	
Pershyttan, nördliche Sjö-Grube	G.	Raw	1866	do	77.7 " "	0.05		0.022	0.006	
Wiker	G.	Roasted	1855	L. Rinman	66.4 per cent. Fe^3 O^4	4.90		0.027	0.044	
Do	G.	Roasted	1870	C. C'son Lindberg	66.1 " "	5.46		0.01	0.04	
Wiker, Erdmanns Schacht	G.	Raw	1866	C. H. Lundström	57.8 " "	5.38		0.034	0.269	
Do	G.	Raw	1870	J. F. Lundberg	57.3 " "	3.66		0.022	0.24	
Wiker, Ekerteeklers Schacht	G.	Raw	1870	do	58.0 " "	3.84		(0.02)	0.23	
Dalkarlsberg, Flint-Grube, Erz No. 1	G.	Raw	1869	B. Fernqvist	87.4 per cent. Fe^2 O^3	0.09		0.029		
Dalkarlsberg, Flint-Grube, Erz No 2	G.	Raw	1869	do	77.7 " "	0.16		0.074		
Dalkarlsberg, Lång-Grube, Erz No. 1	G.	Raw	1869	do	81.2 " "	0.18		0.129	Trace	
Dalkarlsberg, Lång-Grube, Erz No. 2	G.	Raw	1869	do	69.3 " "	0.27	Trace of Cu	0.082	0.005	
Dalkarlsberg, Österrymning	G.	Raw	1859	C. L. Rinman	84.6 per cent. Fe^3 O^4	0.28		0.039	0.03	
Dalkarlsberg, Herr-Grube	G.	Raw	1859	do	88.6 " "	0.25		0.057		
Dalkarlsberg, Ny-Grube, Erz No. 2	G.	Raw	1868	C. H. Lundström	71.6 per cent. Fe^2 O^3	0.38		0.055	0.03	
Dalkarlsberg, Åkers-Grube, Erz No. 1	G.	Raw	1867	do	83.4 " "	0.33		0.031	0.015	
Dalkarlsberg, Orm-Grube, Erz No. 1	G.	Raw	1868	do	82.9 " "	0.14		0.052	0.035	
Dalkarlsberg, Fall-Grube	G.	Raw	1866	do	91.1 per cent. Fe^3 O^4	0.52		0.032	0.035	
Balkarlsberg, Fall-Grube, Erz No. 2	G.	Raw	1865	do	83.2 per cent. Fe^2 O^3	0.24		0.016	0.05	
Rödberg	G.	Raw	1864	B. Fernqvist	87.3 per cent. Fe^3 O^4	0.20	0.16 per ct. Cu	Trace	0.177	
Mo-Grube	G.	Raw	1864	do	94.4 " "	0.04	0.02 per ct. Cu	Trace	0.06	
Parish Winterasa.										
Sanna	G.	Raw	1865	B. Fernqvist	62.5 per cent. Fe^3 O^4	6.49	0.006 per ct. Cu 0.04 per ct. As	0.020	0.126	
Parish Knista.										
Nyberg, Prima Erz	G.	Raw	1871	F. O. Carlin	73.9 per cent. Fe^3 O^4	8.48		(0.01)	(0.07)	

Analyses of Swedish iron-ores—Continued.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Occurring in the ore.					
					Oxide of iron.	Protoxide of manganese.	Copper, cobalt, zinc, &c.	Phosphorus.	Sulphur.	Titanic acid or oxide.
PROVINCE OF ÖREBRO—Continued.										
Parish Nya Kopparberg.										
Långblå, nördlich	G.	Raw	1865	B. Fernqvist	66.0 per cent. $Fe^3 O^4$	0.78	Trace of Cu	0.009	0.041	
Långblå, südliche	G.	Raw	1865	do	67.3 per cent. $Fe^2 O^3$	0.09		0.004	0.023	
Stormossen	G.	Raw	1865	do	65.8 per cent. $Fe^3 O^4$	0.36	Trace of Cu	0.011	0.013	
Elgkärns kulle	G.	Raw	1865	do	63.7 " "	0.36		0.012	0.009	
Carls-Grube	G.	Raw	1865	do	93.7 " "	0.19	Trace of Cu	0.003	0.004	
Smalkärn	G.	Raw	1863	C. H. Lundström	87.9 " "	0.60		0.012	0.04	
Parish Ramsberg.										
Strossa	G.	Raw	1862	L. Rinman	67.5 per cent. $Fe^3 O^4$	0.65		0.004	0.11	
Persberg	G.	Raw	1870	A. Olson	66.7 " "	2.06		0.022		
Parish Linde.										
Gränsbyttan, Moss-Grube	G.	Raw	1862	L. Rinman	77.0 per cent. $Fe^3 O^4$	Trace		0.011	Trace	
Hammarbacken, Gladkärns-Grube	G.	Raw	1868	B. Fernqvist	28.7 per cent. $Fe^2 O^3$	25.8	Trace of As & Ni	0.051	0.076	
Stor-Grube, in d. Nähe v. Hammarbacken	G.	Roasted	1870	J. W. Lewert	*68.1 per cent. $Fe^3 O^4$	10.12				
Stripa	G.	Raw	1862	L. Rinman	42.2 per cent. $Fe^2 O^3$ 40.7 per cent. $Fe^3 O^4$	Trace		0.005	Trace	
Limnäs, Hag-Grube	G.	Raw	1862	do	42.7 " "	3.4		0.015	0.13	
Parish Hellefors.										
Björnhöjd	G.	Raw	1860	C. H. Lundström	69.1 per cent. $Fe^3 O^4$	0.60		0.90	0.06	
Björnhöjd, kleine oder neue	G.	Raw	1864	do	84.9 " "	0.35		0.005	0.030	
Ställberg	G.	Raw	1864	do	79.9 " "	0.15		0.023	0.05	
Åttman	S.	Raw	1867	B. Fernqvist	73.2 " "	1.47	Trace of Cu	0.003	1.818	
Ljungfall	S.	Raw	1867	do	52.7 " "	1.82	do	0.003	1.025	
Mörtkärn	S.	Raw	1867	do	58.0 " "	0.49	do	0.006	0.066	
Nymark	S.	Raw	1867	do	63.8 " "	0.66		0.005	0.015	

Parish Grythytte.										
Högborn, Stoll-Grube	G.	Raw	1862	L. Rinman	80.3 per cent. $Fe^3 O^4$	0.10		Trace	0.01	
Parish Jernboas.										
Rastelf	G.	Raw	1872	B. Fernqvist	62.5 per cent. $Fe^3 O^4$	0.12		0.001	0.011	
Lakäng	G.	Raw	1866	do	79.0 " "	0.06		0.003	0.01	
Parish Nora.										
Striberg, Åsboberg	G.	Raw	1866	C. H. Lundström	86.7 per cent. $Fe^2 O^3$	0.05		0.019	0.05	
Striberg, Svartberg	G.	Raw	1866	do	79.7 per cent. $Fe^3 O^4$	0.45		0.007	0.045	
Striberg, Mossaberg	G.	Raw	1855	L. Rinman	71.5 per cent. $Fe^2 O^3$			0.052		
Striberg, Smedje-Grube	G.	Raw	1866	C. H. Lundström	71.4 " "	0.14		0.016	0.04	
Striberg, Stor-Grube	G.	Raw	1866	do	75.1 " "	0.19		0.023	0.05	
Striberg. Komminister-Grube	G.	Raw	1865	do	76.3 " "	0.07		0.013	0.06	
Striberg, obere Kärr-Grube	G.	Raw	1865	do	76.5 " "	0.14		0.020	0.055	
Lerberg, Djup-Grube	G.	Raw	1862	L. Rinman	83.9 per cent. $Fe^3 O^4$	0.15		0.002	Trace	
Pershyttan, Lock-Grube	G.	Raw	1866	B. Fernqvist	78.9 " "	0.16		0.018	0.007	
Do	G.	Raw	1866	do	75.5 per cent. $Fe^2 O^3$	0.03		0.02	0.025	
Pershyttan, Kittel-Grube	G.	Raw	1866	do	74.6 " "	0.15		0.025	Trace	
Pershyttan, nördliche Sjö-Grube	G.	Raw	1866	do	77.7 " "	0.05		0.022	0.006	
Wiker	G.	Roasted	1855	L. Rinman	66.4 per cent. $Fe^3 O^4$	4.90		0.027	0.044	
Do	G.	Roasted	1870	C. C'son Lindberg	66.1 " "	5.46		0.01	0.04	
Wiker, Erdmanns Schacht	G.	Raw	1866	C. H. Lundström	57.8 " "	5.38		0.034	0.269	
Do	G.	Raw	1870	J. F. Lundberg	57.3 " "	3.66		0.022	0.24	
Wiker, Ekertecklers Schacht	G.	Raw	1870	do	58.0 " "	3.84		(0.02)	0.23	
Dalkarlsberg, Flint-Grube, Erz No. 1	G.	Raw	1869	B. Fernqvist	87.4 per cent. $Fe^2 O^3$	0.09		0.029		
Dalkarlsberg, Flint-Grube, Erz No 2	G.	Raw	1869	do	77.7 " "	0.16		0.074		
Dalkarlsberg, Lång-Grube, Erz No. 1	G.	Raw	1869	do	81.2 " "	0.18		0.129	Trace	
Dalkarlsberg, Lång-Grube, Erz No. 2	G.	Raw	1869	do	69.3 " "	0.27	Trace of Cu	0.082	0.005	
Dalkarlsberg, Österrymning	G.	Raw	1859	C. L. Rinman	84.6 per cent. $Fe^3 O^4$	0.28		0.039	0.03	
Dalkarlsberg, Herr-Grube	G.	Raw	1859	do	88.6 " "	0.25		0.057		
Dalkarlsberg, Ny-Grube, Erz No. 2	G.	Raw	1868	C. H. Lundström	71.6 per cent. $Fe^2 O^3$	0.38		0.055	0.03	
Dalkarlsberg, Åkers-Grube, Erz No. 1	G.	Raw	1867	do	83.4 " "	0.33		0.031	0.015	
Dalkarlsberg, Orm-Grube, Erz No. 1	G.	Raw	1868	do	82.9 " "	0.14		0.052	0.035	
Dalkarlsberg, Fall-Grube	G.	Raw	1866	do	91.1 per cent. $Fe^3 O^4$	0.52		0.032	0.035	
Balkarlsberg, Fall-Grube, Erz No. 2	G.	Raw	1865	do	83.2 per cent. $Fe^2 O^3$	0.24		0.016	0.05	
Rödberg	G.	Raw	1864	B. Fernqvist	87.3 per cent. $Fe^3 O^4$	0.20	0.16 per ct. Cu	Trace	0.177	
Mo-Grube	G.	Raw	1864	do	94.4 " "	0.04	0.02 per ct. Cu	Trace	0.06	
Parish Winteraisa.										
Sauna	G.	Raw	1865	B. Fernqvist	62.5 per cent. $Fe^3 O^4$	6.49	0.006 per ct. Cu 0.04 per ct. As	0.020	0.126	
Parish Knista.										
Nyberg, Prima Erz	G.	Raw	1871	F. O. Carlin	73.9 per cent. $Fe^3 O^4$	8.48		(0.01)	(0.07)	

Analyses of Swedish iron-ores—Continued.

Locality.	General or stufenprobe.	Roasted or raw.	When the assay or analysis was made.	Name of the one who made the analysis.	Occurring in the ore.					
					Oxide of iron.	Protoxide of manganese.	Copper, cobalt, zinc, &c.	Phosphorus.	Sulphur.	Titanic acid or oxide.
IN THE PROVINCE OF WERMLAND.										
Parish Gasborn.										
Fagerberg	G.	Raw	1862	C. H. Lundström	69. 1 per cent. $Fe^3 O^4$	2. 11	0. 12 per ct. Cu	0. 01	0. 33	....
Do	S.	Raw	1867	B. Fernqvist	75. 2 " "	1. 83	....	0. 007	0. 131	....
Do	G.	Roasted	1868	do	65 9 per cent. $Fe^3 O^3$	1. 53	0. 08 per ct. Cu	0. 01	0. 013	....
Hammar	G.	Raw	1863	C. H. Lundström	70. 2 per cent. $Fe^3 O^4$	0. 26	....	0. 01	0. 11	....
Parish Nordmark.										
Taberg, nördlicher	G.	Raw	1863	L. Rinman	77. 8 per cent. $Fe^3 O^4$	0. 25	....	0. 013	0. 045	....
Taberg, kleiner	G.	Raw	1863	do	73. 8 " "	0. 15	....	0. 013	0. 050	....
Do	G.	Raw	1871	C. H. Lundström	70. 9 " "	0. 33	0. 056 per ct. Co. 0. 084 per ct. Zn. Trace of Cu	0. 014	0. 051	....
Nordmark, Berg-Grube	G.	Raw	1863	L. Rinman	76. 3 " "	0. 50	....	0. 007	0. 027	....
Nordmark, Ko-Grube	G.	Raw	1871	C. H. Lundström	74. 7 " "	0. 47	0. 044 per ct Zn. Trace of Cu Trace of Co	0. 000	0. 035	....
Nordmark, Grundsjö und Brattfors	G.	Raw	1863	L. Rinman	82. 7 " "	0. 50	....	Trace	0. 012	....
Finnmossen	G.	Raw	1871	C. H. Lundström	83. 8 " "	0. 43	0. 013 per ct. Co. 0. 014 per ct. Zn. Trace of Cu	0. 011	0. 045	....
Parish Fernebo.										
Långban, Sicilien	G.	Raw	1863	L. Rinman	89. 4 per cent. $Fe^2 O^3$	Trace	....	0. 013	0. 024	....
Persberg, Kran-Grube	G.	Raw	1850	L. F. Svanberg	69. 2 per cent. $Fe^3 O^4$	0. 044	....	....	....	....
Persberg, Skärstöten	G.	Raw	1850	do	75. 1 " "	0. 02	....	....	....	....
Persberg, Torskebäck	G.	Raw	1863	L. Rinman	76. 2 " "	0. 05	....	0. 003	0. 015	....
Persberg, Gustav Adolph	G.	Raw	1864	C. H. Lundström	73. 4 " "	0. 20	....	0. 008	0. 03	....
Persberg, Stor-Grube	G.	Raw	1850	L. F. Svanberg	73. 4 " "	0. 04	....	....	....	....
Persberg, Jordåskärr	G.	Raw	1863	L. Rinman	82. 7 " "	0. 45	....	0. 001	0. 010	....
Persberg, Jordås	G.	Raw	1865	C. H. Lundström	88. 2 " "	0. 16	....	0. 006	0. 06	....

Högberg, Krakbo	G.	Raw	1863	L. Rinman	77.4 " "	0.15	......	0.012	0.01	......
Limkärn	G.	Raw	1863	do	71.6 " "	0.40	......	0.007	0.04	......
Do	G.	Raw	1863	C. H. Lundström	74.7 " "	0.68	......	0.011	0.06	......
Limkärn, südliche oder Nyårs-Grube	G.	Raw	1863	do	77.1 " "	0.35	......	0.01	0.03	......
Kyrkvik	G.	Raw	1867	do	68.3 " "	0.52	......	0.005	0.072	......
Finshyttan, Eng-Grube	G.	Raw	1871	do	75.8 " "	0.57	0.012 per ct. Co Trace of Zn	0.013	0.03	......
Age, Fahlbäck	G.	Raw	1856	C. Ullgren	70.7 " "	0.97	......	0.028	0.207	......
Age, Lejel	G.	Raw	1856	do	64.0 " "	1.16	......	0.025	0.179	......
Mörkhult, Hallsat-Grube	G.	Raw	1856	F. L. Ekman	87.3 " "	0.59	......	Trace	0.02	......
Mörkhult, Mörkhult-Grube	G.	Raw	1856	do	75.6 " "	0.39	......	Trace	......	......
Gas-Grube, Blanka	G.	Raw	1868	C. H. Lundström	87.1 " "	0.37	......	0.016	0.10	......
Nyttsta, Vret-Grube	G.	Raw	1866	do	80.5 " "	0.26	......	0.005	0.07	......
Parish Kroppa.										
Dränke		Raw	1870	C. H. Lundström	72.5 per cent. $Fe^3 O^4$	0.210	0.054 per ct. Cu	0.030	0.055	......
Tallholm	G.	Raw	1871	do	48.6 " " 3.7 per cent. Fe O	0.32	......	0.008	0.023	......
IN THE PROVINCE OF SÖDERMANLAND.										
Parish Floda.										
Staf, alto	G.	Roasted	1859	L. A. v. Celsing	*53.3 per cent. $Fe^3 O^4$	†1.23	......	0.05	......	......
Parish Sköldinge.										
Skalunda, Sophia		Raw	1860	L. E. Boman	79.5 per cent. $Fe^3 O^4$	......	......	0.06	(0.03)	......
Wilhelmina		Raw	1859	C. Wahlund	80.2 " "	0.35	......	0.072	(0.03)	0.3 p. ct. $Ti O^2$.
Parish Åker.										
Skotvång	G.	Roasted	1862	J. A. Kullström	*51.2 per cent. $Fe^3 O^4$	†0.30	(0.08 per ct. Cu.)	(0.032)	(0.02)	......
Parish Gåsinge.										
Elgsjö	G.	Roasted	1862	J. O. Källgren	*62.8 per cent. $Fe^3 O^4$	†0.66	......	(0.04)	(0.03)	......
Parish Svärtuna.										
Förola	G.	Roasted	1858	C. D. Tideström	*77.1 per cent. $Fe^3 O^4$	†0.48	......	0.01	(0.06)	......
Do	G.	Raw	1870	C. H. Lundström	69.1 " "	0.24	0.12 per ct. Cu. and Co.	0.009	0.145	......
Gillinge	G.	Raw	1870	do	63.3 " "	2.42	0.11 per ct. Co.	0.015	0.136	......
Sjösa, Stor-Grube	G.	Raw	1866	O. Aspelin	*43.6 " "	†2.66	......	(0.068)	(0.03)	......

Locality.	The amount of I the ore.	Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances	Silica.	Titanic acid o oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	The analysis is given in—
IN THE PROVINCE OF NORRBOTTEN.														
Tornea Lappmarken, Parish Juckasjervi.														
Kurunavara	*64.0	25.8	1.1	63.2	6.5	3.4	....	13.7	......	0.5	......	0.8	20.6	Anal.-Buchd. Bergschule No. 2, 118.
Luossavara	*71.3	50.0	16.0	1.0	5.3	0.4	17.2 per ct. Ti O^2 10.1 per ct. Ce^2 O^3	26.7	6.7	7.5	2.1	0.1	2.4	Annalen des Eisen-Compt. 1861, p. 250.
Lulea Lappmarken, Parish Gellivara.														
Gellivara, Herzog von Upland	66.7	37.5	12.5	37.5	12.5	......	....	20.0	......	5.9	......	......	15.7	A. d. E. 1862, p. 363.
Gellivara, Törefors und Gyljen	68.1	55.2	14.6	7.8	22.4	......	....	29.4	......	6.9	......	......	8.6	Do.
Gellivara, Tingvalls Hügel	65.7	44.3	12.2	33.5	8.6	......	1.4 per ct. Be O	23.6	......	5.7	0.9	......	13.0	Do.
Gellivara, Robsahm	63.6	50.	8.8	20.2	21.0	......	....	26.7	......	4.1	......	......	14.2	Do.
Gellivara, Wälkomman	63.9	62.	2.7	28.0	6.6	......	....	33.4	......	1.3	......	......	10.6	Do.
Gellivara, Friederike's Schürfen	68.2	57.	8.1	11.5	22.9	Trace.	....	30.7	......	3.8	......	Trace	2.4	Do.
Routivara	54.2	12.	25.2	5.4	18.3	1.9	35.5 per ct. Ti^2 O^3 1.3 per ct. Be O	6.7	11.5	11.7	0.8	0.4	8.8	A. d. E. 1862, p. 364.
Parish Unter-Luleå.														
Hindersö	47.	45.	15.2	11.1	28.2	0.4	....	24.0	......	7.1	......	0.1	14.4	A.-B. d. B. No. 2121.
IN THE PROVINCE OF WEST-NORRLAND.														
Parish Nätra.														
Ulfö	34.2	45.7	12.6	5.3	17.3	1.3	17.6 per ct. Ti O^2....	34.4	6.9	6.0	......	0.3	8.4	A.-B. d. B. No. 1979.
IN THE PROVINCE OF GEFLEBORG.														
Parish Voxna.														
Gymås, Konst-Grube	*35.0	83.5	4.6	7.9	3.3	0.7	....	44.5	......	2.2	......	0.2	3.6	A. d. E. 1860, p. 476.

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag-forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
PROVINCE OF GEFLEBORG—Continued.														
Parish Thorsåker.														
Nyäng, Alte Öster-Grube	*49.3	61.2	5.7	22.5	9.1	1.5	......	32.6	......	2.7	......	0.3	10.1	A. d. E. 1869, p. 389.
Nyäng, Neue Öster-Grube	57.0	53.2	6.7	25.6	13.9	0.6	......	28.3	......	3.1	......	0.1	12.8	
Nyäng, Wester-Grube	50.6	62.8	2.8	17.8	16.4	0.2	......	33.5	......	1.3	......	0.04	11.6	
Nyäng, Noro	35.5	62.9	Trace	3.9	33.2	Trace	......	33.5	......	......	......	......	14.4	
Erik Ers	56.4	32.2	5.2	29.5	13.3	19.8	......	17.2	......	2.4	......	4.5	13.7	A. d. E. 1866, p. 142.
Penning	*43.7	22.9	3.6	15.7	9.3	48.5	......	12.2	......	1.7	......	10.9	8.2	A. d. E. 1864, p. 389.
Do	51.1	34.6	5.0	10.1	9.3	41.0	......	18.5	......	2.3	......	9.2	6.6	
Malmberg	36.9	49.7	8.0	23.5	18.8	Trace	......	26.5	......	3.7	......	......	14.2	
Gösk, Erz No. 3	20.8	32.5	1.7	61.6	3.2	1.0	......	17.3	......	0.8	......	0.2	18.9	A. d. E. 1869, p. 381.
Nyberg	51.3	78.8	11.9	1.8	7.5	Trace	......	42.0	......	5.5	......	......	3.5	
Masmästaren	49.0	53.8	Trace	12.7	30.4	3.1	......	28.7	......	......	......	0.7	15.8	
Fogelmossen	27.8	10.3	0.2	63.2	18.8	7.5	......	5.5	......	0.1	......	1.7	25.5	
Hedberg	55.2	88.0	2.8	0.9	7.7	0.6	......	46.9	......	1.3	......	0.1	3.3	
Afze	18.2	15.7	8.1	59.0	6.4	10.8	......	8.4	......	3.8	......	2.4	19.4	A. d. E. 1864, p. 325.
Afze, Erz No. 1	41.8	17.6	4.1	46.2	22.5	9.6	......	9.4	......	1.9	......	2.2	22.2	
IN THE PROVINCE OF UPSALA.														
Parishes Films and Dannemora.														
Dannemora, Harnäs Hauptgattirung, **1866.**	*54.3	35.4	3.8	31.1	23.7	6.0	......	18.9	......	1.8	......	1.3	18.4	A. d. E. 1869, p. 339.
Dannemora, Nördl. Feld, (die bei **Harnäs gebrauchten Erze** von hier.)	*54.1	47.1	9.1	18.2	20.2	5.4	......	25.1	......	4.3	......	1.2	13.3	A. d. E. 1869, p. 343.
Dannemora, Nördl. Feld, Nördl. Kungs-**Grube.**	51.2	30.3	3.0	27.4	30.0	9.3	......	16.2	......	1.4	......	2.1	19.8	A. d. E. 1866, p. 143.
Dannemora, Zwischenfeld, De Geer, **Jord-Grube.**	56.1	33.3	2.9	23.0	31.6	9.2	......	17.8	......	1.4	......	2.1	19.2	Do.

Dannemora, Südl. Feld, (die bei Harnäs gebrauchten Erze von hier.)	*54. 7	44. 3	5. 5	18. 8	*19. 7	11. 7	....	23. 6	......	2. 6	......	2. 6	13. 2	A. d. E. 1869, p. 343.
Dannemora, Südl. Feld, Südlicher Silfberg.	62. 2	35. 2	6. 5	23. 6	21. 7	13. 0	....	18. 8	......	3. 0	......	2. 9	15. 4	A. d. E. 1866. p. 143.
Parish Alunda.														
Hammarin	*52. 6	31. 0	6. 4	46. 6	8. 6	7. 4	....	16. 5	......	3. 0	......	1. 7	16. 7	A.-B. d. B. No. 2135.
Parish Lena.														
Sahlsta	58. 1	68. 8	9. 1	9. 1	12. 2	0. 8	....	36.	......	4. 3	......	0. 2	7.	A. d. E. 1863, p. 243
Lenaborg, Zwischengrube	*66. 6	45. 1	16. 4	4. 8	22. 7	11. 0	....	24.	......	7. 6	......	2. 5	10.	
Brunna	*59. 2	76. 4	5. 2	4. 0	12. 9	1. 5	....	40. 5	......	2.	......	0. 3	6.	
IN THE PROVINCE OF STOCKHOLM.														
Parish Wahlö.														
Vigelsbo, Stockenströms-Grube	*49. 9	48. 2	14. 0	10. 0	26. 3	1. 5	....	25.	......	6.	......	0. 3	13. 4	A. B. d. B. No. 1826.
Vigelsbo, Myr-Grube	*47. 2	54. 1	10. 3	16. 0	18. 7	0. 9	....	28. 9	......	4.	......	0. 2	9. 9	A. -B.d.B. No. 1830.
Parish Börstil.														
Sand	*53. 8	50. 3	10. 5	30. 1	6. 9	2. 2	....	26. 8	......	4. 9	......	0. 5	11. 4	A. d. E. 1869, p. 390.
Skedika, Nördliche	55. 0	45. 8	18. 9	9. 2	24. 5	1. 6	....	24. 4	......	8.	......	0.	12. 4	A. d. E. 1869, p. 369.
Parish Öregrund or Gräsö.														
Sladdarö	57. 2	67. 3	7. 6	12. 3	11. 6	1. 2	....	35. 9	......	3. 6	......	0.	8. 2	A. d. E. 1863, p. 243.
Parish Häfverö.														
Herräng, Lapp-Grube	53. 1	36. 7	3. 9	39. 1	18. 8	1. 5	....	19. 6	......	1. 8	......	0. 3	16. 5	A. d. E. 1867, p. 252.
Parish Singö.														
Singö, Boudd-Grube	*53. 6	41. 2	19. 1	14. 4	24. 6	0. 7	....	22. 0	......	8. 9	......	0. 2	13. 9	A.-B. d. B. No. 1906.
Parish Österhanninge.														
Utö	*37. 5	87. 1	4. 2	4. 0	3. 3	1. 4	....	46. 5	......	2. 0	......	0. 3	2. 5	A. d. E. 1864, p. 335.
IN THE PROVINCE OF KOPPARBERG.														
Parish Leksand.														
Sörskog. Erz No. 2	*41. 5	63. 4	5. 1	23. 1	5. 4	3. 0	....	33. 8	......	2. 4	......	0. 7	8.	A. d. E. 1860, p. 429.
Parish Åhl.														
Sommarberg	*35. 3	64. 2	10. 7	17. 5	5. 7	1. 9	....	34. 2	......	5. 0	......	0.	7. 3	A. d. E. 1860, p. 469.
Blackberg	*42. 2	59. 3	4. 5	30. 3	4. 9	1. 0	....	31. 6	......	2. 1	......	0. 2	10. 6	A. d. E. 1860, p. 502.

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
PROVINCE OF KOPPARBERG—Continued.														
Parish Svärdsjö.														
Vinkärn, Svartnäs Mischung	46.0	55.5	6.2	30.2	7.7	0.4	....	29.6	......	2.9	......	0.1	11.7	A.-B. d. B. No. 2127.
Vinkärn, Gammel-Grube	*43.1	56.0	9.9	15.0	18.7	0.4	....	29.9	......	4.6	......	0.1	11.8	A. d. E. 1864, p. 421.
Vinkärn, Öster-Grube	*46.4	53.3	8.1	23.0	12.7	2.9	....	28.4	......	3.8	......	0.7	11.6	A. d. E. 1869, p. 384.
Parish Kopparberg.														
Harmsarf	*52.7	58.3	8.8	23.8	8.1	1.0	....	31.1	......	4.1	......	0.2	10.1	A. d. E. 1860, p. 486.
Parish Stora Tuna.														
Hästberg	*50.0	65.0	7.8	23.8	2.2	1.2	....	34.7	......	3.7	......	0.3	7.7	A. d. E. 1859, p. 359.
Hästberg	50.0	50.1	9.8	28.9	9.4	1.8	....	26.7	......	4.6	......	0.4	12.0	A.-B. d. B. No. 2130.
Romme, Örn Grube	*56.2	47.2	9.4	12.9	28.0	2.5	....	24.5	......	4.4	......	0.6	14.8	A. d. E. 1869, p. 345.
Parish Säter.														
Stora Bispberg, Prima Erz	65.0	76.5	2.1	19.7	Trace	1.7	....	40.8	......	1.0	......	0.4	5.6	A.-B. d. B. No. 2123.
Parish Husby.														
Rellingsberg	*61.0	49.3	9.7	23.4	15.0	2.6	....	26.3	......	4.5	......	0.6	12.7	A. d. E. 1869, p. 343.
Rellingsberg, Prima Erz	64.2	50.4	10.5	17.9	17.2	4.0	....	26.9	......	4.9	......	0.9	12.0	A.-B. d. B. No. 2143.
Parish Garpenberg.														
Långvik	*43.2	18.4	2.4	40.6	16.5	22.1	....	9.8	......	1.1	......	5.0	18.2	A. d. E. 1864, p. 303.
Holm	*47.0	37.1	1.9	22.6	15.4	23.0	....	19.8	......	0.9	......	5.2	12.6	A. d. E. 1864, p. 304.
Parish By.														
Vestansjö, Secunda Erz	*40.1	55.7	2.3	30.2	41.0	0.8	....	29.7	......	1.1	......	0.2	13.0	A. d. E. 1860, p. 431.

Parish Folkärna.														
Knutsbo	*44.8	76.0	2.4	7.9	9.3	3.8	......	40.9	......	1.	....	0.9	6.0	A. d. E. 1864, p. 303.
Parish Grangärdes.														
Hästberg oder Fäboback	28.3	29.3	1.3	49.7	4.4	15.3	......	15.6	......	0.	....	3.4	15.9	
Grängesberg:														
Grängesbergsfeld, nördliches, Enkulle-Grube.	57.	77.8	11.7	3.2	7.3	Trace.	......	41.5	......	5.	....	...	3.8	A. d. E. 1861, p. 250.
Grängesbergsfeld, südliches, Bredsjöbrottet.	65.	39.2	22.1	14.1	24.6	......	......	20.9	......	10.	....	...	13.8	Do.
Grängesbergsfeld, südliches, Galthufvud-Grube.	59.9	80.7	10.3	4.2	4.8	......	......	43.0	......	4.8	....	...	3.1	Do.
Ormbergsfeld, östl., Kittel-Grube	57.3	60.8	22.9	3.3	3.9	......	9.1 per cent. Ce^2O^3.	32.4	......	10.	1.9	...	2.5	Do.
Ormbergsfeld, ostl., Björnbytte-u. Badstu-Grube.	56.4	81.	9.5	3.5	3.2	2.7	......	43.2	......	4.	....	0.6	2.3	A. d. E. 1866, p. 287.
Do	57.6	72.9	15.5	7.7	3.9	Trace	......	32.9	......	7.2	....	...	3.7	
Ormbergsfeld, westliches, Tviste Granlund.	56.7	84.4	2.9	6.5	5.6	0.6	......	45.0	......	1.	....	0.1	4.	A. d. E. 1866, p. 287.
Ormbergsfeld, westliches, Abrahams-Grube.	60.9	62.1	9.4	20.5	8.0	......	......	33.1	......	4.	....	...	9.0	A. d. E. 1861, p. 250.
Ormbergsfeld, westliches, Kleine Pick-Grube.	67.6	59.4	19.8	7.9	5.0	......	7.9 per cent. Ce^2O^3.	31.7	......	9.2	1.6	...	4.2	Do.
Bäckberg, Bultar-Grube	*44.1	56.1	11.0	14.7	17.1	1.1	......	29.9	......	5.	....	0.2	11.0	A. d. E. 1864, p. 405.
Parish Ludvika.														
Finnäs, Byberg-Grube	49.9	82.3	5.9	2.2	8.0	1.6	......	43.9	......	2.7	....	0.4	3.8	A. d. E. 1867, p. 251.
Fredmundsberg, Compagnie-Grube	57.3	56.6	6.0	25.1	9.7	0.6	......	31.	......	2.8	....	0.1	11.	A.-B. d. B. No. 1904.
Fredmundsberg, Tägt-Grube	*50.2	47.8	23.4	8.2	13.7	1.9	......	25.5	......	10.9	....	0.4	9.	A. d. E. 1864. p. 341.
Iviken, Lang-Grube	*45.3	77.2	10.0	8.9	1.5	2.4	......	41.2	......	4.	....	0.5	3.1	A. d. E. 1864, p. 324.
Iviken, Lejon-Grube	53.2	73.5	8.8	4.3	11.7	1.7	......	39.	......	4.	....	0.4	5.9	A. d. E. 1861, p. 338.
Iviken, Femman-Grube	35.3	72.0	3.9	6.8	17.0	0.3	......	38.4	......	1.8	....	0.1	8.7	A. d. E. 1860, p. 496.
Iviken, Ko-Grube	55.7	87.7	6.9	3.3	2.1	Trace.	......	46.8	......	3.2	....	...	1.8	A. d. E. 1867, p. 252.
Do	48.6	83.5	1.8	11.9	1.1	1.7	......	44.5	......	0.8	....	0.4	3.8	
Gräsberg, Stor-Grube	47.4	61.0	13.3	24.0	0.9	0.8	......	32.5	......	6.2	....	0.2	7.2	A. d. E. 1867, p. 251.
Gräsberg, Herkules-Grube	52.4	78.3	Trace.	12.9	8.1	0.7	......	41.8	......	......	....	0.2	6.9	Do.
Gräsberg, Kapitän-Grube	*43.7	83.1	6.1	2.7	7.3	0.8	......	44.3	......	2.8	....	0.2	3.	A. d. E. 1860, p. 473.
Gräsberg, Sultin-Grube	46.6	85.1	2.9	5.1	5.1	1.8	......	45	......	1.3	....	0.4	3.	A. d. E. 1867, p. 251.
Haksberg, nördlicher, Släd-Grube	*50.1	88.2	5.3	3.5	2.7	0.3	......	47.0	......	2.5	....	0.1	2.	A.-B. d. B. No. 1901.
Haksberg, nördlicher, Persbo	*50.3	86.9	4.9	4.5	3.6	0.1	......	46.3	......	2.3	....	0.02	2.	A.-B. d. B. No. 1902.
Haksberg, südlicher, Spår-Grube	55.7	85.1	6.7	4.0	3.8	0.4	......	45.	......	3.1	....	0.1	2.	A.-B. d. B. No. 1903.
Parish Norrbärke.														
Östanberg, Smed-Grube	46.5	71.0	7.4	14.2	7.4	......	......	37.9	......	3.4	....	...	7.	A. d. E. 1861, p. 250.
Nyberg, Risberg-Grube	*42.2	61.8	2.4	20.8	14.4	1.6	......	33.0	......	1.1	....	0.4	1.	A. d. E. 1860, p. 475.
Svartberg, Svart Grube	43.9	26.3	2.7	8.9	7.8	54.3	......	14.0	......	1.3	....	12.2	5.6	
Do	41.2	26.7	8.8	6.7	4.7	53.1	......	14.2	......	4.1	....	1.9	3.	

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag-forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
PROVINCE OF KOPPARBERG—Continued.														
Parish Norrbärke.														
Hilläng	37.1	39.7	4.6	19.9	5.7	30.1	......	21.2	......	2.1	......	6.8	7.9	
Torstensberg, nördlicher, Tysk-Grube	48.4	82.4	12.4	Trace.	4.2	1.0	......	43.9	......	5.8	......	0.2	1.7	A. d. E. 1867, p. 251.
Parish Söderbärke.														
Cedercreutz	*38.5	63.3	4.8	12.6	10.2	9.1	......	33.8	......	2.2	......	2.0	7.7	A. d. E. 1869, p. 318.
IN THE PROVINCE OF WESTMANLAND.														
Parish Norberg.														
Norberg:														
Risbergsfeld, Panzar	49.1	75.9	1.0	19.4	3.7	......	......	40.5	......	0.5	......	......	7.0	A. d. E. 1861, p. 121.
Risbergsfeld, Allmänning	50.1	79.3	7.3	7.5	5.4	0.5	......	42.3	......	3.4	......	0.1	4.3	
Risbergsfeld, Spettal	49.9	89.5	1.7	7.9	0.4	0.5	......	47.7	......	0.8	......	0.1	2.4	A. d. E. 1866, p. 144.
Ragvaldsfeld, Förenings-Grube	*54.3	92.3	2.8	1.5	1.8	1.6	......	49.2	......	1.3	......	0.4	1.1	A. d. E. 1864, p. 387.
Snörbergsfeld, Hackspik-Grube	46.3	60.0	1.4	17.2	21.1	0.3	......	32.0	......	0.6	......	0.1	13.3	A. d. E. 1866, p. 246.
Rörbergsfeld, südliche, Hag-Grube	17.1	44.9	7.2	2.1	Trace.	45.8	......	23.9	......	3.4	......	10.3	0.6	
Morbergsfeld, altes, grosse By-Grube	48.4	91.5	1.9	5.4	1.0	0.2	......	48.8	......	0.9	......	0.04	1.9	A. d. E. 1866, p. 246.
Morbergsfeld, altes, Flik	48.0	83.2	1.9	9.6	5.3	......	......	44.4	......	0.9	......	......	4.8	A. d. E. 1861, p. 121.
Do	*47.8	47.9	Trace.	7.2	4.1	0.8	......	46.9	......	......	......	0.2	3.7	A. d. E. 1860, p. 468.
Morbergsfeld, altes, Örling	*49.3	81.0	3.2	9.9	5.2	0.7	......	43.2	......	1.5	......	0.2	4.9	A. d. E. 1864, p. 302.
Kallmorbergsfeld, Norr-Grube	62.1	59.2	Trace.	21.0	18.7	1.1	......	31.6	......	......	......	0.2	13.4	A.-B. d. B. No. 2019.
Kallmorbergsfeld, Svartberg	*46.6	89.4	4.5	2.7	2.4	1.0	......	47.7	......	2.1	......	0.2	1.7	A. d. E. 1864, p. 386.
Kallmorbergsfeld, Torf-Grube, westl. Schacht	63.7	83.5	3.5	7.8	1.5	3.7	......	44.5	......	1.6	......	0.8	2.8	A.-B. d. B. No. 2116.
Bålsjöbergsfeld, grosse Badstu-Grube	60.6	76.0	6.5	14.0	3.2	0.3	......	40.5	......	3.0	......	0.07	5.3	
Bålsjöbergsfeld, kleine Badstu-Grube	55.5	91.8	4.9	2.4	0.7	0.2	......	49.0	......	2.3	......	0.04	1.0	A. d. E. 1866, p. 246.
Bålsjöbergsfeld, Holm-Grube	51.6	82.2	10.6	5.2	1.2	0.8	......	43.8	......	5.0	......	0.2	2.0	
Klackbergsfeld, Näsberg	30.1	23.6	1.0	60.1	11.9	3.4	......	12.6	......	0.5	......	0.8	21.9	A. d. E. 1866, p. 141.

[illegible]	[illegible]	[illegible]	......	[illegible]	[illegible]	[illegible]	....	11.5	.....	......	......	8.7	13.5	A. d. E. 1861, p. 121.
Do.	55.0	17.4	11.5	6.7	5.9	58.5	....	9.3	.....	5.4	......	13.2	6.1	
Röjmossfeld, neue Kron Grube	50.6	86.7	3.3	6.8	2.4	0.8	....	46.2	.....	1.5	......	0.2	2.9	A. d. E. 1866, p. 247.
Stripåsfeld, kleine Ny-Grube	*31.1	56.5	8.5	22.5	12.5	Trace.	....	30.1	.....	4.0	......	......	11.4	A. d. E. 1864, p. 396.
Stripåsfeld, Redvägs-Grube	*50.7	91.3	6.1	1.5	Trace.	1.1	....	48.7	.....	2.8	......	0.2	0.4	A. d. E. 1864, p. 385.
Parish Westanfors.														
Flinthed	53.2	53.0	2.7	9.7	21.4	13.2	....	28.3	.....	1.3	......	3.0	11.3	
Stortägt, ötsliche, bei Semla	48.4	82.0	3.9	6.4	5.3	2.4	....	43.7	.....	1.8	......	0.5	3.9	
Parish Skinnskatteberg.														
Bastnäs, grosse Lång-Grube	46.0	87.1	4.1	4.3	4.5	Trace.	....	46.4	.....	1.9	......	......	3.0	A. d. E. 1860. p. 455.
Parish Sala.														
Springan	50.2	60.2	12.0	20.6	4.7	2.5	....	32.1	.....	5.6	......	0.6	7.7	A. d. E. 1860, p. 387.
Badstu-Grube in d. Nähe von Springan	*38.7	77.0	5.2	11.7	5.0	1.1	....	41.1	.....	2.4	......	0.2	7.3	A. d. E. 1864, p 328.
Ny-Grube in d. Nähe von Springan	*38.2	57.1	8.9	26.9	3.6	3.5	....	30.4	.....	4.1	......	0.8	9.1	A. d. E. 1864, p. 327.
Lugndal	*41.0	17.2	7.7	65.1	0.2	9.8	....	9.2	.....	3.6	......	2.2	18.7	A. d. E. 1859, p. 334.
IN THE PROVINCE OF ÖREBRO.														
Parish Nya Kopparberg.														
Grängesberg:														
Lombergsfeld, Dam-Grube	*53.3	81.7	12.3	1.9	3.6	0.5	....	43.6	.....	5.7	......	0.1	2.0	A. d. E. 1869, p. 357.
Lombergsfeld, Storbotten	49.9	85.3	8.4	3.9	2.0	0.4	....	45.5	.....	3.9	......	0.1	1.9	A. d. E. 1864, p. 209.
Lombergsfeld, Fall-Grube	54.7	82.8	10.0	3.8	1.9	1.5	....	44.2	.....	4.7	......	0.3	7.3	Do.
Slättfall	62.3	72.3	8.9	10.3	1.5	1.0	....	38.6	.....	4.1	......	0.2	5.9	
Svartvik	48.0	36.3	7.8	28.9	17.0	10.0	....	19.4	.....	3.6	......	2.3	15.0	A. d. E. 1864, p. 209.
Svartvik, Qvarn-Grube	58.2	39.1	4.6	19.4	19.7	17.2	....	20.9	.....	2.1	......	3.9	13.4	A. d. E. 1862, p. 365.
Ställberg, Kungs-Grube	*46.9	34.0	1.9	32.1	14.1	17.9	....	18.1	.....	0.9	......	4.0	14.8	A.-B. d. B. No. 1837.
Källfall	63.8	55.5	6.4	18.1	19.4	0.6	....	29.6	.....	3.0	......	0.1	12.9	
Laugblå, nördliche	47.8	69.2	4.3	19.5	4.7	2.3	....	36.9	.....	2.0	......	0.5	7.4	
Långblå, südliche	47.1	97.2	0.9	1.0	0.6	0.3	....	51.8	.....	0.4	......	0.1	0.5	
Stormossen	47.7	77.7	3.5	14.4	3.3	1.1	....	41.4	.....	1.6	......	0.2	5.4	
Elgkärns kulle	46.2	66.0	5.2	20.2	5.6	1.0	....	36.3	.....	2.4	......	0.2	8.0	
Carls-Grube	67.9	62.8	8.0	15.9	10.3	3.0	....	33.5	.....	3.7	......	0.7	8.6	
Smalkärn	63.6	60.4	12.0	17.8	5.0	4.8	....	32.2	.....	5.6	......	1.1	7.1	A. d. E. 1864, p. 209.
Parish Ramsberg.														
Strossa	48.8	85.9	7.1	1.8	3.2	2.0	....	45.8	.....	3.3	......	0.5	1.8	A. d. E. 1862, p 365.
Persberg	48.3	30.6	16.9	4.9	41.1	6.5	....	16.3	.....	7.5	......	1.5	17.8	A.-B. d. B. No. 1840.
Parish Linde.														
Gränshyttan, Moss-Grube	55.7	90.8	4.0	3.0	2.2	Trace	....	48.4	.....	1.9	......	......	1.7	A. d. E. 1862, p. 365.
Hammarbacken, Gladkärns-Grube	20.1	47.9	0.6	12.8	2.7	36.0	....	25.5	.....	0.3	......	8.1	4.7	

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag-forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
PROVINCE OF ÖREBRO—Continued.														
Parish Linde.														
Stor-Grube in d. Nähe v. Hammarbacken	49.3	81.5	8.8	4.4	4.9	0.4	....	43.5	......	4.1	......	0.1	3.2	A.-B. d B. No. 1854.
Stripa	59.0	78.9	2.8	8.9	9.4	Trace	....	42.1	......	1.3	......	......	6.3	A. d. E. 1862, p. 365.
Limnäs, Hag-Grube	30.9	13.3	5.5	37.8	33.4	10.0	....	7.1	......	2.6	......	2.3	12.2	Do.
Parish Hellefors.														
Björnhöjd	50.0	50.9	11.5	23.4	12.3	1.9	....	27.1	......	5.4	......	0.4	11.6	A. d. E. 1861, p. 338.
Björnhöjd, kleine oder neue	61.5	65.3	6.1	13.5	12.8	2.3	....	34.8	......	2.8	......	0.5	8.8	A. d. E. 1865, p. 236.
Ställberg	57.8	55.7	15.9	7.7	19.9	0.8	....	29.7	......	7.4	......	0.2	10.1	Do.
Åttman	53.0	38.0	7.3	7.3	41.2	6.2	....	20.3	......	3.4	......	1.4	18.5	
Ljungfall	38.1	43.5	4.1	6.5	41.7	4.2	....	23.2	......	1.9	......	0.9	18.5	
Mörtkärn	42.0	46.9	2.8	5.1	44.0	1.2	....	25.0	......	1.3	......	0.3	19.0	
Nymark	44.2	49.1	3.0	5.3	40.7	1.9	....	26.2	......	1.4	......	0.4	17.8	
Parish Grythytte.														
Högborn, Stoll-Grube	58.1	50.4	9.1	21.7	18.3	0.5	....	26.9	......	4.2	......	0.1	13.5	A. d. E. 1862, p. 365.
Parish Jernboas.														
Rastelf	45.3	58.0	4.3	24.9	12.5	0.3	....	30.9	......	2.0	......	0.1	12.1	
Lakälbg	57.2	60.6	8.0	6.8	24.3	0.3	....	32.3	......	3.7	......	0.1	11.6	
Parish Nora.														
Striberg, Åsboberg	60.7	60.6	19.4	10.5	9.1	0.4	....	32.3	......	9.0	......	0.1	6.6	A. d. E. 1866, p. 287.
Striberg, Svartberg	57.7	73.5	5.6	8.0	10.7	2.2	....	39.2	......	2.6	......	0.5	6.5	A. d. E. 1867, p. 150.
Striberg, Mossaberg	50.0	85.9	10.2	Trace	3.9	......	....	45.8	......	4.8	......	......	1.5	A. d. E. 1861, p. 119.
Striberg, Smedje Grube	49.9	91.4	1.4	5.6	1.1	0.5	....	48.7	......	0.6	......	0.1	2.0	A. d. E. 1867, p. 150.
Striberg, Stor-Grube	52.6	94.0	2.8	1.2	1.2	0.8	....	50.1	......	1.3	......	0.2	0.8	Do.

Striberg, Komminister-Grube	53.5	91.7	1.9	5.8	1.0	0.3		48.9		0.6		0.1	2.0	A. d. E. 1866, p. 287.
Striberg, obere Kärr-Grube	53.6	91.4	1.9	5.1	1.0	0.6		48.7		0.9		0.1	1.8	Do.
Lerberg, Djup-Grube	60.7	75.0	8.7	5.3	10.0	1.0		40.0		4.0		0.2	5.5	A. d. E. 1862, p. 365.
Pershyttan, Lock-Grube	57.1	85.3	9.9	2.2	1.9	0.7		45.5		4.6		0.2	1.4	
Do	52.9	84.4	10.0	3.3	2.2	0.1		45.0		4.7		0.02	1.8	
Pershyttan, Kittel-Grube	52.2	82.4	12.8	1.8	2.4	0.6		43.9		6.0		0.1	1.4	
Pershyttan, nördliche Sjö-Grube	54.4	85.9	8.8	2.4	2.7	0.2		45.8		4.1		0 04	1.7	
Wiker	48.1	44.3	13.1	6.1	22.2	14.3		23.6		6.1		3.2	10.6	A. d. E. 1861, p. 119.
Do	47.9	42.2	8.4	4.6	29.2	15.6		22.5		3.9		3.5	13.0	A. B. d. B., No. 1897.
Wiker, Erdmanns Schacht	41.8	35.7	7.7	6.7	31.1	18.8		19.0		3.6		4.2	14.3	A, d. E., 1867, p. 151.
Do	41.5	38.4	7.7	8.3	32.7	12.9		20.5		3.6		2.9	15.4	A. d. E., 1871, p. 364.
Wilker, Ekertecklers Schacht	41.9	40.0	6.8	6.8	33.6	12.8		21.3		3.2		2.9	15.3	Do.
Dalkarlsberg, Flint-Grube, Erz No. 1	61.2	55.5	6.1	12.0	25.8	0.6		29.6		2.8		0.1	13.7	
Dalkarlsberg, Flint-Grube, Erz No. 2	54.4	57.0	5.7	8.6	23.0	0 7		30.4		2.7		0.2	13.6	
Dalkarlsberg, Lång-Grube, Erz No. 1	56.8	51.1	8.4	13.0	26.5	1.0		27.2		3.9		0.2	14.3	
Dalkarlsberg, Lång-Grube, Erz No. 2	48.5	52.6	9.7	9.2	27.6	0.9		28.0		4.5		0.2	13.5	
Dalkarlsberg, Österrymning	61.2	45.9	30.8	7.9	13.3	2.1		24.5		14.4		0.5	7.5	A. d. E., 1860, p. 357.
Dalkarlsberg, Herr-Grube	64.1	46.3	21.8	12.2	17.5	2.2		24.7		10.2		0.5	10.4	A. d. E., 1860, p. 356.
Dalkarlsberg, Ny-Grube, Erz No. 2	50.1	56.3	8.1	8.5	25.7	1.4		30.0		3.8		0.3	12.7	A. d. E., 1869, p. 221.
Dalkarlsberg, Åkors-Grube, Erz No. 1	58.4	62.9	9.1	7.2	18.9	1.9		33.5		4.2		0.4	9.6	A. d. E., 1868, p. 410.
Dalkarlsberg, Orm-Grube, Erz No. 1	58.0	57.5	16.2	3.7	21.8	0.8		30.7		7.5		0.2	10.0	A. d. E., 1869, p. 221.
Dalkarlsberg, Fall-Grube	65.9	49.3	16.5	5.5	22.4	6.3		26.3		7.7		1.4	10.5	A. d. E., 1867, p. 151.
Dalkarlsberg, Fall-Grube, Erz No. 2	58.2	62.1	10.4	2.8	23.2	1.5		33.1		4.8		0.3	10.0	A. d. E., 1866, p, 287.
Rödberg	63.2	63.2	14.5	7.9	12.8	1.6		33.7		6.8		0.4	7.3	
Mo-Grube	68.3	55.2	17.3	7.6	19.2	0.7		29.4		8.1		0.2	9.8	
Parish Winterůsa.														
Sanna	45.3	23.2	0.3	26.1	28.1	22.3		12.4		0.1		5.0	18.7	
Parish Knista.														
Nyberg, Prima Erz	53.5	44.0	6.0	7.3	8.6	34.1		23.5		2.8		7.7	5.5	A. B. d. B., No. 1886.
IN THE PROVINCE OF WERMLAND.														
Parish Gåsborn.														
Fagerberg	50.0	45.3	8.7	32.8	6.2	7.0		24.2		4.0		1.6	11.8	A. d. E., 1863, p. 268.
Do	54.4	44.1	4.0	24.4	20.2	7.3		23.5		1.9		1.6	15.0	
Do	46.1	49.8	6.3	23.4	16.1	4.4		26.6		2.9		1.0	13.1	
Hammar	50.8	70.2	6.2	1.7	21.0	0.9		37.4		2.9		0.2	8.9	A. d. E., 1864, p. 209.
Parish Nordmark.														
Taberg, nördlicher	56.3	57.4	7.2	10.5	23.7	1.2		30.6		3.4		0.3	12.4	A. d. E., 1863, p. 243.
Taberg, kleiner	53.4	59.5	5.6	11.2	23.1	0.6		31.7		2.6		0.1	12.4	Do.
Do	51.3	61.2	2.2	11.4	24.0	1.2		32.6		1.0		0.3	12.8	A. d. E., 1872, p. 225.
Nordmark, Berg-Grube	55.2	56.2	5.8	17.2	18.6	2.2		30.0		2.7		0.5	12.3	A. d. E., 1863, p. 243.
Nordmark, Ko-Grube	54.1	53.6	3.6	22.2	18.8	1.8		28.6		1.7		0.4	13.8	A. d. E., 1872, p. 226.

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag-forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
PROVINCE OF WERMLAND—Continued.														
Parish Nordmark.														
Nordmark, Grundsjö und Brattfors	59.8	56.9	4.1	22.7	13.4	2.9	......	30.3	......	1.9	......	0.7	11.8	A. d. E. 1863, p. 243.
Finnmossen	60.7	52.3	6.8	15.5	22.8	2.6	......	27.9	......	3.2	......	0.6	13.5	A. d. E. 1872, p. 225.
Parish Fernebo.														
Långban, Sicilien	62.6	80.8	5.4	5.9	7.9	Trace	......	43.1	......	2.5	......	......	4.8	A. d. E. 1863, p. 243.
Persberg, Kran-Grube	50.1	58.1	9.5	14.2	18.1	0.1	......	31.0	......	4.4	......	0.02	11.3	A. d. E. 1852, p. 190.
Persberg, Skärstöten	54.3	55.5	10.0	6.3	28.1	0.1	......	29.6	......	4.7	......	0.02	13.0	Do.
Persberg, Torskebäck	55.2	57.5	3.7	23.0	15.6	0.2	......	30.7	......	1.7	......	0.04	12.8	A. d. E. 1863, p. 213.
Persberg, Gustav Adolph	53.1	51.0	5.0	21.0	22.3	0.7	......	27.2	......	2.3	......	0.2	14.9	A. d. E. 1865, p. 237.
Persberg, Stor-Grube	53.1	57.1	11.2	11.9	12.6	0.2	......	30.4	......	5.2	......	0.04	11.2	A. d. E. 1852, p. 190.
Persberg, Jordåskärr	59.8	55.0	6.0	24.3	12.1	2.6	......	29.3	......	2.8	......	0.6	11.7	A. d. E. 1863, p. 243.
Persberg, Jordås	63.8	53.5	10.2	24.4	10.4	1.5	......	28.5	......	4.8	......	0.3	11.1	A. d. E. 1866, p. 287.
Persberg, Östra Hagen	56.2	62.8	3.1	15.1	19.0	Trace	......	33.5	......	1.4	......	......	11.9	A. d. E. 1863, p. 243.
Persberg, Väg-Grube	59.6	54.4	7.3	11.0	26.0	1.3	......	29.0	......	3.4	......	0.3	13.5	A. d. E. 1866, p. 287.
Persberg, Nord-Grube	54.2	58.7	3.1	13.7	23.5	1.0	......	31.3	......	1.4	......	0.2	13.3	A. d. E. 1863, p. 243.
Persberg, Nord-Grube, nördliche	52.7	64.2	2.1	5.1	28.1	0.5	......	34.4	......	1.0	......	0.1	12.7	A. d. E. 1866, p. 287.
Persberg, Dunderbacken	57.4	82.7	5.5	5.4	5.5	0.9	......	44.1	......	2.6	......	0.2	3.7	Do.
Högberg, Krakbo	56.0	55.7	3.9	33.2	6.5	0.7	......	29.7	......	1.8	......	0.2	12.1	A. d. E. 1863, p. 243.
Limkärn	51.8	53.9	4.3	32.3	8.0	1.5	......	28.7	......	2.0	......	0.3	12.4	Do.
Do	54.1	45.8	15.8	29.0	6.7	2.7	......	24.4	......	7.4	......	0.6	10.9	A. d. E. 1864, p. 209.
Limkärn, südliche oder Nyårs-Grube	55.8	51.8	8.6	23.9	14.2	1.5	......	27.6	......	4.0	......	0.3	12.5	Do.
Kirkvik	49.	52.8	8.0	24.5	13.1	1.6	......	28.1	......	3.7	......	0.4	12.2	A. d. E. 1868, p. 410.
Finshyttan, Eng-Grube	54.9	51.4	6.6	14.7	24.7	2.6	......	27.4	......	3.1	......	0.6	14.0	A. d. E. 1872, p. 225.
Age, Fahlbäck	51.2	54.5	4.4	17.2	20.5	3.4	......	29.1	......	2.0	......	0.8	13.1	A. d. E. 1861, p. 110.
Age, Lejel	46.3	51.2	11.3	14.4	19.8	3.3	......	27.3	......	5.3	......	0.7	12.0	A. d. E. 1861, p. 111.
Mörkhult, Hallsat-Grube	63.2	51.3	5.8	22.0	16.5	4.4	......	27.4	......	2.7	......	1.0	12.9	A. d. E. 1861, p. 113.
Morkhult, Mörkhult-Grube	54.7	56.0	5.8	24.4	12.3	1.5	......	29.9	......	2.7	......	0.3	11.9	A. d. E. 1861, p. 112.
Gås-Grube, Blanka	63.	50.7	6.7	19.4	20.5	2.7	......	27.0	......	3.1	......	0.6	13.7	A. d. E. 1869, p. 221.
Nyttsta, Vret-Grube	58.3	50.6	6.4	6.4	35.3	1.3	......	27.0	......	3.0	......	0.3	15.9	A. d. E. 1867, p. 151.

Parish Kroppa.														
Dräkte	52. 5	54. 4	7. 6	16. 2	21. 0	0. 8	....	29. 0	......	3. 5	......	0. 2	13. 0	
Tallholm	38. 0	56. 6	3. 8	23. 9	15. 0	0. 7	....	30. 2	......	1. 8	......	0. 2	12. 8	A. d. E. 1872, p.
IN THE PROVINCE OF SÖDERMANLAND.														
Parish Floda.														
Staf, alte	*38. [illegible]	78. 3	6. 2	6. 7	5. 9	2. 9	....	41. 8	......	2. 9	......	0. 7	4. 3	A. d. E. 1860, p. 463.
Parish Sköldinge.														
Skalunda, Sophia	57. 6	75. 1	18. 7	5. 2	1. 0	......	....	40. 0	......	8. 7	......	......	1. 8	A. d. E. 1860, p. 513.
Wilhelmina	58. 1	49. 0	38. 1	9. 5	Trace.	1. 8	1. 6 per cent. Ti O² ..	26. 1	0. 6	17. 7	......	0. 4	2. 7	A. d. E. 1860, p. 459.
Parish Åker.														
Skotvång	*37. 1	85. 2	1. 3	7. 4	5. 4	0. 7	....	45. 4	......	0. 6	......	0. 2	4. 3	A. d. E. 1864, p. 335.
Parish Gåsinge.														
Elgsjö	*49. 8	84. 5	4. 1	4. 8	4. 1	2. 5	....	45. 1	......	1. 9	......	0. 6	3. 0	A. d. E. 1864, p. 343.
Parish Svärtuna.														
Förola	*55. 9	90. 6	4. 2	2. 6	0. 4	2. 2	....	48. 3	......	2. 0	......	0. 5	0. 9	A. d. E. 1860, p. 399.
Do	50. 1	79. 0	3. 8	4. 7	11. 7	0. 8	....	42. 1	......	1. 8	......	0. 2	6. 0	
Gillinge	45. 8	75. 4	4. 5	8. 0	5. 3	6. 8	....	40. 2	......	2. 1	......	1. 5	4. 4	
Sjösa, Stor-Grube	*31. 6	59. 1	8. 8	25. 5	1. 7	4. 9	....	31. 5	......	4. 1	......	1. 1	7. 9	A. d. E. 1869, p. 354.
Parish Jerna.														
Jerna	*62. 4	76. 5	12. 4	4. 5	6. 3	0. 3	....	40. 8	......	5. 8	......	0. 1	3. 8	A. d. E. 1860, p. 411.
IN THE PROVINCE OF ÖSTERGÖTLAND.														
Parish Mogata.														
Petäng	*44. 8	55. 5	11. 2	18. 9	12. 8	1. 6	....	29. 6	......	5. 2	......	0. 4	10. 5	A. d. E. 1860, p. 423.
Parish Skällsvik.														
Nartorp, Prima Erz	*46. 6	57. 5	2. 8	32. 1	7. 1	0. 5	....	30. 7	......	1. 3	......	0. 1	12. 0	A. d. E. 1860, p. 505.
Do	*44. 3	57. 7	5. 7	26. 3	8. 8	1. 5	....	30. 8	......	2. 7	......	0. 3	11. 0	A. d. E. 1869, p. 361.
IN THE PROVINCE OF CALMAR.														
Parish Ukna.														
Stenebo	*54. 7	80. 4	9. 6	3. 2	5. 2	1. 6	....	42. 9	......	4. 5	......	0. 4	3. 0	A. d. E. 1860, p. 400.

Analyses of Swedish iron-ores—Continued.

Locality.	The amount of iron in the ore.	The amount of slag-forming constituents of the ore.						Oxygen content of the slag-forming constituents.						The analysis is given in—
		Silica.	Alumina.	Lime.	Magnesia.	Protoxide of manganese.	Other substances.	Silica.	Titanic acid or oxide.	Alumina.	Oxide of cerium and glucina.	Protoxide of manganese.	Lime and magnesia.	
IN THE PROVINCE OF JÖNKÖPING.														
Parish Mansarp.														
Taberg	31.5	39.8	10.4	3.1	34.2	0.7	11.8 per cent. Ti O²	21.2	4.6	4.8	......	0.2	14.5	A. d. E. 1866, p. 143.
IN THE PROVINCE OF KRONOBERG.														
Parish Ryssby.														
Långhult	38.3	33.3	20.1	4.0	22.9	0.7	19.0 per cent. Ti O²	17.8	7.4	9.4	......	0.2	10.3	A. d. E. 1866, p. 247.

[*] This per cent. of iron was not found in the ore itself, but in the product obtained by the crucible-assay, 96 per cent. of the weight of the regulus being added to the iron found in the slag, and the per cent. of oxide in the ore being reckoned from the amount of metallic iron thus found.

[†] The per cent. of protoxide of manganese was not found in the ore itself, but was reckoned from the amount found in the slag, when the crucible-assay was made with the most acid mixture possible. The numbers inclosed in parentheses do not indicate the amounts found in the ore itself, but the percentages found in the regulus, when the crucible-assay was made with the most acid mixture possible.

CHAPTER VI.

SPAIN, RUSSIA, AND SIBERIA.

SPANISH IRON-MINES; ARRANGEMENT OF THE OBJECTS; EXTENT AND CONDITION OF THE IRON-INDUSTRY OF THE RUSSIAN EMPIRE IN 1871; IMPORTS AND EXPORTS; PRODUCT OF IRON-ORES AND OF CAST IRON; IRON AND STEEL; LIST OF IRON-WORKS IN THE RUSSIAN EMPIRE; PRODUCTION OF COAL; LIST OF COLLIERIES; PETROLEUM AND CHROMIC IRON; OTHER MINERALS AND METALS.

143. SPAIN.—A number of the iron-mines of Spain were represented by samples. It is well known that a large amount of money has been invested in Spanish iron-mines by British capitalists. Although it has been provided by legislative authority that no export-duty shall be imposed upon ores before the year 1881, an attempt was made to collect a duty of about 25 cents a ton, but this failed through the protests of the English, French, and German governments. A duty of about 13 cents is exacted by the municipality of Bilbao. The capacity of production and of export of Spanish ores is important to the iron-industry of the United States, especially as a certain amount of these ores are imported for the manufacture of spiegel iron.

The number and distribution of the iron-mines of Spain, together with the production for the years 1869 and 1870, are shown in the following tabular statement:

Provinces.	1869.		1870.	
	No. of mines.	Produce in quintals.	No. of mines.	Produce in quintals.
Almeria	6	87, 200	6	87, 600
Badajos	6	24, 000	6	28, 000
Biscay	75	1, 618, 000	75	2, 503, 575
Búrgos	2	3, 318	3	7, 500
Córdoba	1	4, 000	1	2, 000
Gerona	2	2, 238	8	1, 962
Guadalajara	4	4, 651	....	....
Guipúzco	29	184, 970	29	159, 000
Leon	10	13, 950	10	9, 319
Logroño	5	36, 320	5	18, 029
Lugo	1	9, 443	1	10, 880
Malaga	7	103, 860	8	200, 070
Múrcia	14	135, 500	14	157, 528
Navarre	8	114, 740	8	77, 640
Orense	1	5, 359	....	....
Oviedo	56	335, 492	49	694, 525
Santander	36	345, 387	29	352, 420
Seville	6	32, 077	6	32, 392
Tarragona	3	500	1	250
Teruel	2	8, 400	2	11, 000
Toledo	3	14, 000	6	12, 180
Total	....	3, 113, 405	....	4, 365, 870

149. THE IRON-MANUFACTURES OF RUSSIA.—The iron and steel display from Russia is arranged very tastefully in the alcoves between the high columns of the main nave. Upon a crimson-cloth background, surmounted by a gilded imperial crown, the manufactures of the imperial works, consisting of sword-blades and other material of war, are skillfully displayed, as if they were trophies. Parts of cannon, steel shot and shell, chain-cables, rails, and bar-iron are grouped at the base, together with huge masses of the ore. The display by Pontiloff is similarly arranged, but consists chiefly of steel and iron rails radially disposed above a monumental mass of ores. In Prince Demidoff's exhibition the iron-ores are grouped with polished masses of malachite. Broken steel ingots, and copper ingots, also broken to show the grain, stand side by side. There is also a fine group of polished iron rods, tied in knots, without showing a crack or flaw, and of rails twisted into ringlets, to prove their extreme toughness and uniformity.

The famous sheet-iron of the country is shown in sheets of all sizes and degrees of thickness, and specimens the size of visiting-cards have been freely distributed. Among the more instructive and novel parts of the collections are models of iron-works showing the roofs supported upon a series of semicircular iron arches springing from the level of the floor; a series of drawings of Rachette's furnaces, and maps showing the extent of the mineral industries of the empire. The iron-metallurgists of Russia are not behind those of Europe in the introduction of new and improved methods. Great advances have been made in the production of cast steel on a large scale, and in the manufacture of steel guns of large caliber, several of which are exhibited from the works of Oboukoff. The largest is a 12-inch rifled breech-loader, weighing 81,000 pounds. There are fine groups of railway tires, axles, and other railroad-material, from the same establishment. Rachette's system of furnaces is extensively used, and is said to give remarkable results. The Bessemer and Siemens-Martin processes, for the production of steel, are successfully introduced.

149. *Statistics.*—An interesting *résumé*, by the mining engineer Skalkovsky, of the mining-industry of Russia, with statistical tables of the production of iron and other metals, was distributed by the Russian commission,[*] and is the source of the following data and general observations. The iron-industry was diminishing. In 1870 there were 1,283 works in operation, and 1,174 in 1871. Of steel, 536,086 pounds were produced in 1870, and 442,241 in 1871. The production of cast iron was slightly greater in 1871 than in 1870, as shown in the following table, giving a general view of the extent and condition of the iron-industry of Russia in 1870 and 1871:

	1870.	1871.
Cast iron, (pouds[†])	21,959,326	22,004,518
Wrought iron, (pouds)	15,217,908	14,958,597

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[*] *Tableaux statistiques de l'Industrie des Mines en Russie en 1871, par C. Skalkovsky, Ingénieur des Mines.* St. Petersburg, 1873. 8vo., pamphlet, pp. 40.

[†] The Russian poud is equivalent to 16.3808 kilograms.

	1870.	1871.
Steel, (pouds)	536,086	442,241
Iron and steel works, (number)	214	214
High furnaces, (number)	245	222
Puddling-furnaces, (number)	445	431
Refining-furnaces, (number)	692	667
Forges, (number)	924	818
Steel-furnaces, (number)	495	372

The imports and exports of iron and steel in 1872 were as follows:

	Imports, pouds.		Exports, pouds.	
	Europe.	Asia.	Europe.	Asia.
Cast iron	2, 923, 305	....	14, 947	....
Wrought iron	13, 890, 817	5	262, 714	46, 084
teel	812, 355	4, 211	....	4, 853

A full list is given of the iron-works of the empire, with their production for the year 1871. The two following tabular statements are condensed from the list:

Table of production of iron-ore and of cast iron in the Russian Empire in 1871, (*in pouds.*)

[One Russian poud = 16. 3808 kilograms.]

No. of works.	Establishments.	Ores extracted.	Ore and slag smelted.	Cast iron.	
				Pig-iron.	Various objects.
12	Pertaining to the crown	4, 216, 593	5, 055, 954	2, 120, 121	150, 370
2	Cabinet of His Imperial Majesty	142, 300	161, 720	50, 661	11, 051
5	Private works, Ural	27, 094, 4[illegible]	25, 297, 043	11, 1[illegible]1, 017	1, [illegible]07, 436
6	Private works about Moscow	[illegible], 3[illegible]1, 93[illegible]	7, 147, 711	2, 3[illegible]9, 725	[illegible]5, 23[illegible]
1	Private works, Caucasus	53, 671	69, [illegible]02	[illegible], 1[illegible]0	10, [illegible]03
8	Private works, western and southern provinces	1, 370, 512	1, 373, 5[illegible]7	323, 729	22, 34[illegible]
2	Private works, Siberia	53[illegible], 903	53[illegible], 903	274, 5[illegible]1	30, [illegible]
3	Crown works, kingdom of Poland	1, 05[illegible], 115	563, 470	177, 663	[illegible]
1	Private works, kingdom of Poland	5, 444, 397	5, 261, 453	1, 17[illegible], 576	235, 111
5	Private works, Finland	2, 522, 751	3, 077, 449	1, 230, 191	....
	Grand totals	50, [illegible]23, 66[illegible]	4[illegible], [illegible]67, 152	1[illegible], [illegible]54, 634	3, 149, [illegible]75
				22, 004, [illegible]	

Table of production of iron and steel in the Russian Empire in 1871, (*in pouds.*)

[One Russian poud = 16. 3808 kilograms.]

works.	Establishments.	Bar iron.	Sheet-iron.	Steel.
3	Crown works	[illegible]	139 [illegible]	11[illegible] [illegible]
2	Cabinet of His Imperial Majesty	17 1[illegible]	1 2[illegible]0	[illegible]1
8	Private works, Ural	[illegible]	2 4[illegible] 1[illegible]	[illegible]
9	Private works about Moscow	1 [illegible] [illegible]4	1[illegible] 411	....
1	Private works, Caucasus	1 217	....	....
2	Private works, Siberia	12[illegible] [illegible]91	1[illegible] [illegible]	[illegible]
3	Works not under the mining administration	2 [illegible] [illegible]	[illegible] 1[illegible]	[illegible]
4	Crown works, Poland	12[illegible] [illegible]	1 [illegible]	....
6	Private works, Poland	[illegible] [illegible]24	4[illegible] [illegible]	....
5	Private works, Finland	[illegible] [illegible]	1, [illegible]	[illegible]
	Total	11 [illegible] 4[illegible]	2 [illegible]	44[illegible] [illegible]

The Russian Mining Journal, 1872, presents a statement of the production of cast and wrought iron in the Ural district for each successive ten years, commencing from 1797, as follows:*

Period.	Cast iron.		Wrought iron.	
	Pouds.	Tons.	Pouds.	Tons.
1797–1807	6, 435, 342	103, 794	3, 820, 067	61, 613
1807–1817	6, 307, 108	101, 743	3, 993, 144	64, 405
1817–1827	6, 836, 560	110, 268	4, 568, 263	73, 681
1827–1837	7, 549, 167	121, 760	4, 987, 351	80, 441
1837–1847	8, 413, 758	136, 028	5, 830, 761	94, 044
1847–1857	9, 923, 467	160, 055	7, 046, 205	113, 648
1857–1867	12, 480, 827	201, 303	8, 021, 561	129, 380

150. IRON-WORKS IN THE RUSSIAN EMPIRE.—The following is a list of the imperial, royal, and private iron-works in the Russian Empire, with their production of iron and steel in the year 1871:†

Production of iron-ore and of cast iron.

Works.	Iron-ore mined.	Iron ore and slag smelted.	Production of cast iron.	
			Pig-iron.	Various objects.
A.—*Crown works.*	*Pouds.*	*Pouds.*	*Pouds.*	*Pouds.*
1. Kamensky	562, 500	512, 598	162, 335	49, 814
2. Zlatooustofsky	259, 865	252, 268	109, 798	6, 655
3. Satkinsky	400, 000	648, 002	305, 959	5, 763
4. Koucinsky	350, 000	420, 011	151, 259	21, 218
5. Kouchvinsky	2, 039, 345	1, 012, 235	531, 106	19, 933
6. Barantchinsky		585, 891	325, 342	17, 712
7. Verkhnié-Tourinsky		291, 295	158, 787	1, 765
8. Peskovsky	480, 521	869, 850	240, 278	23, 329
9. Licitchansky	23, 543	94, 374	30, 972	....
10. Kontchosersky	....	75, 297	21, 386	66
11. Soudiarvsky	100, 819	164, 775	42, 905	3, 816
12. Valazminsky	....	129, 358	39, 894	169
Total	4, 216, 593	5, 055, 954	2, 120, 121	130, 379
B.—*Works pertaining to the cabinet of the Emperor.*				
13. Gouriévsky	42, 300	47, 770	19, 117	1, 734
14. Pétrovsky	100, 000	113, 950	31, 544	9, 317
Total	142, 300	161, 720	50, 661	11, 051
C.—*Private work, Ural.*				
15. Nigenié Saldinsky	4, 565, 327	27, 633	13, 428	3, 253
16. Nigenié-Taghilsky		1, 471, 628	806, 064	163, 604
17. Verkhnié-Saldinsky		1, 256, 023	691, 076	117, 161
18. Vicimo-Chaïtansky		521, 826	321, 536	22, 281
19. Verkh-Isetsky	184, 850	348, 629	173, 968	31, 548
20. Réjevskoï	180, 972	489, 352	261, 408	27, 559
21. Verkhniéneïvinsky	10, 000	131, 389	65, 571	8, 674
22. Neïvinskoroudiansky	205, 000	404, 809	215, 190	31, 891
23. Verkhnié-Taghilsky	128, 215	518, 811	260, 878	46, 886
24. Outkinsky, (Jakovlev)	140, 000	321, 794	119, 756	66, 614
25. Néïvo Alapaïevsky	1, 053, 458	1, 055, 458	477, 333	37, 917
26. Néïvo Chaïtansky	378, 262	378, 262	186, 323	23, 947
27. Verkhnié-Siniatchikhinsky	558, 764	558, 764	248, 739	13, 492
28. Néviansky	799, 981	575, 934	265, 086	43, 693
29. Pétrokamensky	260, 941	244, 566	104, 946	24, 997
30. Nigenié-Serghinsky	475, 894	382, 760	148, 231	72, 497
31. Verkhnié-Serghinsky	526, 250	297, 683	116, 521	8, 843
32. Kychtymsky	821, 508	597, 449	264, 237	52, 000
33. Kaslinsky	462, 224	338, 270	167, 750	15, 691
34. Niasépétrovsky	544, 970	303, 386	120, 011	48, 252
35. Sycertsky	1, 436, 570	1, 087, 204	522, 005	42, 599
36. Siéversky	517, 000	493, 851	200, 654	59, 673
37. Molebsky	279, 722	245, 277	105, 376	15, 638
38. Outkinsky, (Souksounsky)	410, 160	463, 906	208, 257	23, 112

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*Cited in Jour. Iron and Steel Institute, by David Forbes, F. R. S., &c. I, 1873, p. 221.

†From Skalkovsky's *Tableaux statistiques*, at the Vienna Exhibition.

Production of iron-ore and of cast iron—Continued.

Works.	Iron-ore mined.	Iron ore and slag smelted.	Production of cast iron.	
			Pig-iron.	Various objects.
-*Private work, Ural*—Continued.	*Pouds.*	*Pouds.*	*Pouds.*	*Pouds.*
vdinsky	676, 036	676, 036	349, 403	22, 101
itansky	320, 227	320, 227	120, 138	29, 612
genié-Irghinsky	186, 937	150, 891	40, 616	13, 463
évolodovilvensky	251, 115	226, 776	70, 568	......
xandrovsky	263, 400	208, 303	62, 646	7, 277
ermosky	735, 268	250, 993	108, 280	21, 210
elovsky		609, 949	290, 960	22, 010
ghangelo-Pachyisky, (1870)	668, 998	616, 797	211, 705	69, 214
ucié-Alexandrovsky, (1870)	443, 303	490, 735	178, 121	28, 036
novskoï	229, 735	425, 609	152, 733	44, 057
imbaïevsky	804, 554	934, 242	381, 163	88, 256
nvinsky, (1870)	495, 960	744, 856	291, 319	24, 372
svensky	359, 902	276, 956	98, 461	14, 975
ersky	292, 986	226, 994	93, 927	7, 327
rkhnié-Oufaléïsky	713, 008	544, 533	269, 697	23, 825
genié-Oufaléïsky	661, 615	574, 522	233, 249	55, 143
rusansky	523, 000	478, 404	253, 207	38, 749
tav-Ivanovsky	1, 026, 490	847, 622	427, 530	83, 163
sky	747, 324	460, 535	204, 730	56, 322
olaévsky		209, 568	69, 318	49, 420
loretsky	499, 110	280, 725	146, 607	34, 705
lansky		186, 673	105, 649	10, 167
rkhnié-Avsianopétrovsky	560, 000	546, 624	226, 373	33, 774
outninsky	1, 195, 097	1, 072, 116	325, 997	29, 786
rkhnié-Zalazninsky	350, 382	136, 342	37, 681	6, 279
azninsko-Biéloretsky	......	160, 954	30, 633	......
mkovsko-Borovskoï	624, 100	557, 452	175, 144	34, 379
ernokholounitsky	405, 772	443, 689	142, 573	13, 790
ourmonikolsky	21, 163	......	......	......
outchpasky	72, 448	50, 515	12, 944	1, 060
ouvchimsky	26, 490	27, 642	5, 935	3, 021
Total	27, 094, 488	25, 287, 043	11, 181, 017	1, 807, 436
.—*Private works around Moscow.*				
ksounsky	1, 145, 765	790, 718	328, 842	13, 999
vedsky		669, 652	265, 713	......
ngensky	51, 100	63, 676	23, 543	......
nciévsky	229, 852	272, 990	92, 719	13, 074
rkhnié-Oungensky	140, 000	136, 085	54, 172	3, 485
rskoï	862, 800	809, 085	382, 816	24, 155
chinsky	312, 019	324, 811	153, 506	4, 048
ratcharovsky	390, 000	387, 936	178, 106	6, 662
rdouchinsky	295, 000	235, 032	88, 030	7, 245
ngnensky	212, 315	195, 812	56, 942	51, 820
etinsky	190, 819	105, 819	21, 929	13, 402
etsko-Ivanovsky	268, 294	177, 296	37, 493	32, 057
udinovsky	1, 425, 000	736, 693	160, 705	172, 229
kremensky				
no-Serghievsky	350, 000	247, 169	80, 826	12, 173
sotchinsky, (de Maltzof)	432, 128	403, 175	77, 380	96, 434
sotchinsky, (de Krivorotof)	232, 035	193, 998	28, 161	62, 375
hérépetsky	145, 956	144, 313	44, 573	40, 486
gdano-Pétrovsky	107, 900	105, 708	27, 942	22, 332
chegsky	378, 000	336, 268	47, 025	108, 935
atoulsky	350, 000	251, 178	46, 915	46, 765
insko-Zalipiagesky	125, 000	109, 162	32, 966	14, 478
tochevsky	172, 383	161, 331	26, 472	32, 927
garsky	10, 500	......	......	......
ubensky	155, 072	240, 675	42, 686	75, 547
atoursky	100, 000	21, 129	10, 263	700
Total	8, 381, 938	7, 147, 711	2, 309, 725	855, 238
E.—*Private works, Caucasus.*				
atakhsky	53, 671	69, 862	8, 180	10, 803
-*Private works, western and central provinces.*				
iét. de la Nouvelle Russie	163, 289	163, 289	34, 472	......
tishtchensky	619, 700	494, 100	128, 099	4, 060
dnia		125, 600	35, 280	......
échovsky	12, 000	(?)14, 000	10, 000	5, 975
xandra	450, 673	450, 673	28, 298	......
sòkaïa Petche	5, 600	6, 675	3, 600	2, 553
tka	111, 200	111, 200	20, 200	8, 000
ns de pet. usines	8, 050	8, 050	3, 780	1, 740
Total	1, 370, 512	1, 373, 587	323, 729	22, 348

Production of iron-ore and of castiron—Continued.

Works.	Iron-ore mined.	Iron-ore and slag smelted.	Production of cast iron.	
			Pig-iron.	Various objects.
G.—*Private works, Siberia.*				
	Pouds.	*Pouds.*	*Pouds.*	*Pouds.*
105. Abakansky	338, 571	338, 571	167, 132	22, 693
106. Nikolaïévsky	200, 332	280, 332	107, 449	8, 195
Total	538, 903	538, 903	274, 581	30, 888
H.—*Works of the crown, kingdom of Poland.*				
107. Bankovsky	284, 220	291, 217	97, 369	5, 105
108. Pankovsky	112, 885	99, 397	32, 638	11, 351
109. Réïefsky	661, 010	202, 860	47, 856	10, 174
Total	1, 058, 115	593, 470	177, 864	26, 630
J.—*Private works, kingdom of Poland.*				
110. Ostrovetzky	450, 000	453, 634	120, 000	5, 000
111. Strakovitzky	800, 000	500, 000	140, 141	9, 963
112. Falkovsky	111, 250	111, 250	20, 300	2, 825
113. Khmelevsky	200, 000	150, 000	30, 000	15, 000
114. Bodsekovsky	160, 000	155, 000	40, 000	3, 500
115. Drzevitzky	308, 900	302, 840	25, 605	30, 125
116. Przisouksky	166, 375	153, 125	37, 125	...
117. Bialatchevsky	45, 687	136, 862	22, 075	10, 517
118. Koritkovsky	146, 000	146, 000	29, 200	...
119. Malenetzky	202, 718	229, 161	41, 615	4, 870
120. Makhoraksky	152, 857	152, 521	35, 590	...
121. Rzouzovsky	175, 600	162, 700	38, 520	...
122. Blizinsky	93, 940	82, 208	7, 002	13, 550
123. Ninkovsky	133, 500	133, 500	28, 000	...
124. Khlevissky	592, 286	700, 936	158, 144	5, 697
125. Neclansky	177, 862	231, 962	66, 747	3, 131
126. Borkovitzky	203, 550	196, 800	42, 165	...
127. Konsky	382, 935	346, 850	95, 712	2, 104
128. Krasniensky	40, 600	90, 600	11, 754	6, 070
129. Chtchezinsky	98, 550	72, 750	11, 250	8, 562
130. Fidor	53, 000	53, 000	21, 750	...
131. Okrad zénov	...	?	45, 000	...
132. Poremba Mziglozka	14, 400	?	38, 551	...
133. Maslonsk	...	...	...	...
134. Miatchev	9, 000	(?)21, 000	20, 000	...
135. Bliakhovnia	151, 810	218, 393	330	53, 882
136. Staraia Kousnitza	204, 979	204, 979	5, 000	35, 000
137. Inovledz	80, 000	76, 000	21, 000	...
138. Przistan	76, 250	76, 650	6, 000	25, 375
139. Goustek	...	102, 732	20, 000	...
140. Mines of Vélune and Bendine, (1870)	212, 347	...	...	...
Total	5, 444, 397	5, 261, 453	1, 178, 576	235, 111
K.—*Private works, Finland.*				
141. Tiké	2, 522, 751	225, 565	114, 592	...
142. Koskis		130, 332	49, 920	...
143. Dals		357, 565	181, 627	...
144. Hegfors		63, 999	19, 050	...
145. Skegbi		70, 467	27, 483	...
146. Soumboula		20, 904	7, 150	...
147. Vertsilé		434, 980	162, 605	...
148. Mekhké		382, 236	146, 006	...
149. Stremsdal		167, 762	53, 206	...
150. Loupikko		375, 928	137, 355	...
151. Kartula		215, 238	66, 643	...
152. Irkakoski		51, 095	21, 247	...
153. Ekatérinensky		146, 244	50, 669	...
154. Haapakosky		218, 452	87, 450	...
155. Oravi		238, 692	105, 178	...
Total	2, 522, 751	3, 077, 449	1, 230, 181	...
Grand total	50, 823, 668	48, 567, 152	18, 854, 634	3, 149, 884
Grand total of cast iron	...	...	22, 004, 518	

Production of iron, and of steel.

Works.	Iron in bars and rods.	Sheet-iron of all kinds.	Steel, cast and hammered.
A.—*Crown works.*	*Pouds.*	*Pouds.*	*Pouds.*
1. Nigenié-Icetsky	67, 703	12, 852	....
2. Zlatooust Kuiasé-Mikhaïlovsky	11, 423	....	....
3. Koucinsky	13, 567	....	....
4. Satkinsky	....	....	44, 778
5. Artinsky	41, 328	....	1, 417
6. Nigenié-Tourinsky	51, 479	33, 835	459
7. Sérébriansky	79, 324	....	....
8. Permsky staleponchetchny	....	4, 763	64, 440
9. Votkinsky	157, 946	71, 560	976
10. Kamsky	111, 393	5, 402	....
11. Kirsinsky	134, 705	11, 117	....
12. Lougansky	14, 469	....	....
13. Alexandrovsky	2, 048	....	....
Total	585, 385	139, 529	112, 070
B.—*Works pertaining to the cabinet of the Emperor.*			
15. Gourievsky	8, 643	....	....
16. Pétrovsky	8, 465	1, 220	251
Total	17, 108	1, 220	251
C.—*Private works, Ural.*			
17. Nigenié-Taghilsky	....	254, 934	15, 552
18. Laisky			
19. Nigenié-Saldinsky	448, 292	915	11, 956
20. Verkhnié-Saldinsky			
21. Vicimôoutkinsky	218, 427	....	....
22. Visimochaitansky			
23. Tschernôistotchinsky	34, 282	262, 855	....
24. Verkhnié-Isetsky	2, 930	102, 034	5, 601
25. Réjevskoï	16, 485	219, 367	....
26. Verkhnié-Néïvinsky	291	131, 618	....
27. Nigeny-Verkhnié-Néïvinsky			
28. Néivinsko-Roudiansky	201	....	....
29. Nigeny-Roudiansky			
30. Molebskoï			
31. Chouralinsky	337	....	....
32. Verkhnié-Taghilsky			
33. Vogoulsky			
34. Outkinsky	3, 501	2, 350	....
35. Schaitansky			
36. Sylvensky	1, 696	....	....
37. Sarghinsky			
38. Néïvo-Alapaïevsky	232, 503	156, 678	....
39. Verkhnié-Siniatchikhinsky			
40. Néïvo-Chaïtansky	824	226, 441	....
41. Irbitsky	18	....	....
42. Néviansky	126, 447	....	....
43. Pétrokamensky	134, 927	....	....
44. Nigenié-Serghinsky	48, 625	....	....
45. Verkhnié-Serghinsky	116, 244	....	....
46. Kosinsky	395	....	....
47. Atigsky	268	....	....
48. Mikhaïlovsky	195, 182	....	....
49. Kychtymsky	219, 485	....	....
50. Kaslinsky	15, 622	45, 213	....
51. Niasépétrovsky	10, 426	112, 207	....
52. Chemakhinsky	12, 826	....	....
53. Sycertsky	271, 744	....	....
54. Ilinsky	57, 425	42, 790	....
55. Polevskoy			
56. Verkh-Sycertsky	166, 462	....	....
57. Siéversky	39, 288	....	....
58. Souksounsky	28, 566	....	....
59. Tissovsky	23, 104	....	....
60. Kambarsky	18, 093	17	....
61. Outkinsky	41, 043	....	....
62. Molebsky	3, 749	....	....
63. Revdinsky	177, 386	....	....
64. Bissertsky	125, 457	....	....
65. Rojestvensky	47, 337	....	....

Production of iron, and of steel—Continued.

Works.	Iron in bars and rods.	Sheet iron of all kinds.	Steel, cast and hammered.
C.—*Private works, Ural*—Continued.	*Pouds.*	*Pouds.*	*Pouds.*
66. Chaïtansky	58, 583	7, 340	
67. Irghinsky	46, 013		
68. Saraninsky	19, 401		
69. Knaoufsky	5, 942		
70. Pojevskoï	1, 625	74, 150	
71. Elisavéto-Pojevskoï		56, 800	
72. Vsiévolodovilvensky	1, 115		
73. Alexandrovsky	4, 731		
74. Nikitinsky		142, 360	
75. Tchermosky	45, 745	148, 541	
76. Kisélovsky			
77. Polazninsky	107, 409		
78. Khokhlovsky	38, 761		
79. Kynovskoï	28, 077	70, 152	
80. Bilimbaïëvsky	4, 496		
81. Dobriansky			
82. Sophyisky			
83. Nytvensky	183, 749		
84. Otchersky, (1870)	15, 461		
85. Pavlovsky, (1870)		212, 278	
86. Lysvensky	195, 738		
87. Bicersky	33, 391		
88. Kousié-Alexandrovsky, (1870)	2, 136		
89. Archangelo-Pachiysky, (1870)	43, 809		
90. Jougokamsky, (1870)	67, 138	517	
91. Verkhnié-Oufaléïsky	10, 225		
92. Nigenié-Oufaléïsky	215, 765		
93. Jouruzansky	140, 440		10, 019
94. Minsky	1, 173		1, 232
95. Kataf-Ivanovsky	250, 771	23, 206	11, 966
96. Oust-Katafsky	108, 017		4, 239
97. Simsky	40, 303		3, 898
98. Miniarsky	160, 262	2, 249	
99. Biéloretsky	144, 620		
100. Tirliansky	58, 645		
101. Verkhnié-Avsianopétrovsky	84, 983		
102. Nigenié-Avsianopétrovsky	81, 281		
103. Kajimsky	136		
104. Nioutchpasky	701		
105. Niouvtchimsky	5, 837		
106. Omoutninsky	117, 137	28, 111	
107. Poudemskoï	2, 048	33, 935	
108. Zalazninsky	25, 258		
109. Nigenié-Zalazninsky	23, 347		
110. Kholounitsky	128, 875	99, 134	165
111. Bogorodsky			
112. Tchernokholounitsky	3, 396		
113. Chourminsky	16, 156		
114. Bouïsky	35, 492		
Total	5, 254, 076	2, 456, 192	70, 975
D.—*Private works around Moscow.*			
115. Gousievskoï	69, 567		
116. Vyksounsky	302, 421	8, 799	
117. Snovedsky	24, 005		
118. Verkhniégélieznitsky	109, 307		
119. Véletminsky	140, 810		
120. Doschato-Gélieznitsky	30, 294	38, 280	
121. Jérémchinsky	24, 278		
122. Merdouchinsky	55, 950		
123. Karatcharovsky	133, 855		
124. Ilevsky	253, 550		
125. Voznécensky			
126. Tachinsky	80, 090		
127. Lioudinovsky	279, 581	57, 595	
128. Soukremensky			
129. Ivano-Serghievsky	71, 786	1, 337	
130. Pessotchinsky, (of M. Maltzof)	8, 774		
131. Sérensky	23, 051		
132. Istinsko-Zalipiagesky	10, 977		
133. Pétrovsky	8, 068		
134. Sentourisky	24, 500		
Total	1, 650, 864	196, 011	

Production of iron, and of steel—Continued.

Works.	Iron in bars and rods.	Sheet-iron of all kinds.	Steel, cast and hammered.
E.—*Private works, Caucasus.*	*Pouds.*	*Pouds.*	*Pouds.*
khsky	1, 217	....	....
F.—*Private works, Siberia.*			
sky	72, 945	12, 234	380
evsky	50, 436	4, 698	236
otal	123, 381	16, 932	616
ot under the jurisdiction of the administration of mines.			
de l'Amirauté	18, 481	32, 508	....
ovsky de l'Amirauté	....	....	142, 369
(Ministre de la Guerre)	41, 508	....	5, 735
	131, 015	160, 500	....
a	1, 399, 019		
Poutilof		....	....
société des chemins de fer	696, 873	7, 793	....
sky	127, 731	27, 297	....
y	39, 055	....	....
Roukavichnikof	....	....	20, 500
S. Piatof	....	....	25, 100
tchensky	117, 987	....	....
dra	71, 715	....	....
etablishments	5, 434	....	....
otal	2, 648, 818	228, 198	193, 704
H.—*Works of the crown, kingdom of Poland.*			
dnief	1, 740	....	....
	74, 509	....	....
sky	53, 223	....	....
	488	1, 055	....
otal	129, 960	1, 055	....
I.—*Private works, kingdom of Poland.*			
tzky	3, 000	....	....
vitzky	175, 056	3, 750	....
sky	32, 957	....	....
hovsky	35, 000	30	....
ovsky	760	....	....
ksky	83, 200	15, 500	....
evsky	13, 122	....	....
tzy	33, 322	13, 560	....
raksky	2, 000	....	....
vsky	28, 240	....	....
y	5, 069	....	....
sky	144, 774	2, 366	....
sky	7, 381	....	....
itzki	2, 350	....	....
	10, 570	....	....
	6, 250	....	....
nsky	52, 820	....	....
nsky	5, 405	1, 552	....
nitzky	3, 000	....	....
	16, 000	....	....
ef	2, 500	....	....
tovsky	5, 014	....	....
evsky	7, 000	....	....
zky	1, 762	....	....
	5, 000	....	....
	1, 300	....	....
vsky	3, 130	....	....
	8, 000	....	....
	136, 000	....	....
ovsky	30, 000	....	....
y	5, 750	....	....
	5, 700	....	....
	10, 550	....	....
a	950	....	....

Production of iron, and of steel—Continued.

	Works.	Iron in bars and rods.	Sheet-iron of all kinds.	Steel, cast and hammered.
	I.—*Private works, kingdom of Poland*—Continued.	*Pouds.*	*Pouds.*	*Pouds.*
190.	Konezpol	1,586	12,120	....
191.	Rembelidzé	6,010	....	....
	Total	890,524	48,278	....
	J.—*Private works, Finland.*			
192.	Matildadal	39,232	....	....
193.	Dalsbrouk	94,409	....	....
194.	Hegfors	14,563	....	....
195.	Fiskars	87,464	....	....
196.	Stremsdal	39,187	....	....
197.	Vertsilé	109,849	....	....
198.	Ekaterinensky	73,288	1,560	64,625
199.	Fridérixfors	17,035	....	....
200.	Kiriakkala	14,551	....	....
201.	Jokkis	7,177	....	....
202.	Viérou	8,533	....	....
203.	Kimé	12,756	....	....
204.	Orisberg	9,407	....	....
205.	Bilnès	13,078	....	....
206.	Fagbervik	10,951	....	....
207.	Mariéfors	14,705	....	....
208.	Sverté	20,466	....	....
209.	Kantoua	7,023	....	....
210.	Stremfors	10,439	....	....
211.	Norrmark	6,767	....	....
212.	Nésé	1,132	....	....
213.	Irkekoski	7,273	....	....
214.	Varkaous	3,544	....	....
215.	Oravi	733	....	....
216.	In Catalan forges	34,727	....	....
	Total	658,289	1,560	64,625
	Grand total	11,959,622	2,998,975	442,241
	Grand total of bar, rod, and sheet iron	14,958,597		

There is a large consumption of iron and copper in the manufactures of Russia, notably in the manufacture of artillery-arms, machinery, and iron vessels, but the statistics of these manufactures are acknowledged to be very imperfect, inasmuch as some one hundred and fifty establishments for working iron do not report to the government mining department. And the working of iron to a great extent is not confined wholly to large establishments; there are entire districts where the peasants are exclusively occupied in working iron during the winter. For these reasons the following figures represent only a small part of the extent of metal-work in Russia in the year 1871:

	Pouds.
Steel cannon	15,682
Apparatus	20,493
	46,175
Cast-iron cannon	51,485
Munitions of artillery	405,831
Iron boats	7,868

Cast-iron work:	Pouds.
cupolas	1,306,110
reverberatory furnaces	584,169
	1,890,279
comotives	3,596
on-work	850,831
pper and steel work	36,813
	Pieces.
pper and steel work	287,440
de-arms	40,708
rm-apparatus	30,326
ythes	33,750

51. PRODUCTION OF COAL IN RUSSIA.—The production and distribu-
n of mineral coal, petroleum, and salt in Russia are shown by the an-
xed tabular list of collieries, &c., which lists are important in connec-
n with the foregoing lists of iron-works:

Collieries in Russia.

Name and location.	Coal.	Anthracite.	Bituminous, shale, and lignite.
A.—*Moscow coal-basin.*	*Pouds.*	*Pouds.*	*Pouds.*
Malëvsky	1,316,839		
Tovarkovsky	760,560		
Novoselebny	1,300,000		
Jacenetsky	200,000		
Slaviansky	5,000		
Zelenensky	150,000		
Mouraevinsky	1,145,000		
Tchoulkovsky	2,000,000		
Paveletzky	1,800,000		
Total	8,677,399		
B.—*Elisabetgrad basin.*			
Ekatérinopolsky			300,000
Djourovsky			700,000
Total			1,000,000
C.—*Donetz coal-basin.*			
(*a*) Territory of the Cossacks of the Don.			
Grouchevsky		10,603,467	
Bolche-Nesvitaïsky		35,757	
Vlassovsky Ryghinsky Bambétof Bérestovsky		478,371	
Territories of Tcherkask, Donetz, and of the Don		876,239	
Private collieries. Arrondissement de Miouss		2,115,621	
(*b*) In the government of Ekaterinoslaf.			
MINES OF THE CROWN.			
Licitchansky	500,761		
PRIVATE MINES.			
First district.			
Nikitovsky, (M. Poliakoff)	265,000		
Volyntzevsky	7,217		
Alexandrovsky	530,181		

Production of chrome-iron ore.

Sources.	Number of mines.	Pouds.
Private mines in the Ural.		
1. Verkh-Icetsky	2	237, 665
2. Kychtimsky	1	54, 897
3. Chaïtansky	1	109, 964
4. Oufaleïsky	2	49, 127
Total	6	450, 973

Production of salt.

Sources.	Pouds.
A.—*Rock-salt.*	
MINES.	
1. Iletskaïa Zachtchita	1, 048, 567
2. Mont Tchiptchatchi	802, 638
3. Koulpinsky	1, 012, 212
4. Nakhitchévansky	203, 625
Total	3, 067, 042
B.—*Salt obtained by evaporation.*	
WORKS.	
5. Dédioukhinsky	2, 477, 743
6. Lenvensky	3, 699, 373
7. Oussolsky	3 390, 690
8. Solikamsky	935, 605
9. Ledengsky	170, 264
10. Totemsky	6, 865
11. Sérégovsky	233, 538
12. Nénoksky	69, 965
13. Kouloisky	429
14. Ounsky	8, 173
15. Loudsky	3, 836
16. Small works on the borders of the White Sea	5, 569
17. Balakhninsky	26, 628
18. Slaviansky	151, 624
19. Troïtsky	100, 801
20. Oustekoutsky	42, 744
21. Irkoutsky	330, 555
Total	11, 654, 596
C.—*Salt from salt lakes.*	
SALT LAKES.	
22. Elton	370, 000
23. D'Astrakhan	4, 379, 086
24. Gaidouksky	235, 618
25. Mojarsky	497, 763
26. De Crimée	6, 257, 015
27. Kouyalnitsky	715, 287
28. Tchalghinsky	201, 095
29. Du Transcaucase	345, 265
30. Manytchsky des Cosaques du Don, (1870)	124, 680
31. Des Cosaques du Kouban, (1870)	82, 776
32. Indersky des Cosaques de l'Oural, (1870)	192, 200
33. Borovya et Aléouskya	30, 426
34. Borsinsky	90, 581
35. Jakoutsky	11, 100
Total	13, 532, 892
Grand total	28, 254, 530

In the concluding tables a general view is presented of the total production of the mines and metallurgical works of the Russian Empire in the years 1870 and 1871.

eneral table of the production of the mines and metallurgical works of Russia, 1870 *and* 1871.

	1871.	1870.
Washings.	*Pouds.*	*Pouds.*
uriferous sand	1, 081, 518, 424	983, 475, 095
latiniferous sand	10, 440, 650	9, 609, 150
Extracted by washing.	*Poud. liv. zol. gr.*	*Poud. liv. zol. gr.*
ashed gold	2, 399 38 2 8	2, 156 23 16 19
rude platinum	125 6 56 0	118 38 33 0
Extracted from mines.	*Pouds.*	*Pouds.*
rgentiferous lead-ore	2, 177, 540	2, 116, 404
opper-ore	6, 222, 759	6, 392, 622
on-ore	50, 823, 668	48, 763, 156
nc-ore	2, 629, 477	2, 666, 754
in-ore	22, 909	66, 292
obalt-ore	649	1, 249
or vitriol, (pyrites excepted)	50, 000	95, 000
al	50, 654, 552	43, 230, 589
raphite	....	....
troleum	1, 375, 523	1, 704, 455
romic iron	450, 973	600, 024
lt	28, 254, 530	29, 013, 458
Smelted.		
rgentiferous lead-ore	1, 892, 636	2, 066, 792
opper-ore	6, 384, 154	7, 190, 213
on-ore	48, 567, 152	48, 464, 114
nc-ore	1, 665, 495	2, 117, 318
n-ore	?	?
Products obtained.	*Poud. liv. zol.*	*Poud. liv. zol.*
lver from the ores	828 30 27	867 30 68
ad	107, 963 26 0	100, 653 20 0
pper	260, 006 31 0	308, 440 0 0
n	475 0 0	1, 032 0 9
	Pouds.	*Pouds.*
g-iron	18, 854, 634	18, 557, 412
st iron in different forms	3, 149, 884	3, 401, 914
Total of cast iron	22, 004, 518	21, 959, 326
nc, crude	166, 581	221, 328
st iron from cupolas	1, 306, 110	1, 343, 891
st iron from reverberatory furnaces	452, 239	620, 851
Total of cast iron	1, 890, 279	1, 964, 742
on in bars, rods, rails, &c	11, 959, 622	11, 971, 459
on in sheets	2, 998, 975	3, 246, 449
Total of iron	14, 958, 597	15, 217, 908
eel	442, 241	536, 086
pper, in sheets	21, 277	29, 642
nc, in sheets	30, 000	26, 844
balt matte	....	305½
on-work	850, 831	958, 634
ork in other metals	36, 813	53, 885
triol, &c	4, 605	9, 910
	Roubles.	*Roubles.*
tal of different mints	11, 254, 744	33, 545, 643
Now working.	*Number.*	*Number.*
ld-mines	979	1, 208
atina-mines	6	6
gentiferous lead	21	26
nes of copper	76	71
nes of iron	1, 174	1, 283
nes of zinc	6	6
nes of cobalt	1	1
nes of tin	1	1
nes of coal	327	193
nes of graphite	....	....
nes of pyrites	1	2
nes of chromic iron	6	9
nes of rock-salt	4	4
urces of petroleum	697	7 7

General table of the production of the mines and metallurgical works of Russia, 1870 *and* 1871—Continued.

	1871.	1870.
	Number.	*Number.*
Mints	2	2
Refineries for gold	2	2
Silver-works	9	10
Copper-works	35	39
Cast-iron works	153	164
Zinc-works	5	4
Cobalt-works	....	1
Tin-works	1	1
Works producing iron and steel	214	214
High-furnaces	222	245
Puddling-furnaces	431	445
Refinery-furnaces	667	692
Forges	818	994
Steel-furnaces	372	495
Cupola-furnaces	150	161
Reverberatory-furnaces	93	93
Copper-furnaces	247	262
Silver-furnaces	130	130
Zinc-furnaces	141	128
Steam-engines	515	482
Power of engines	14, 477	13, 730
Water-motors	2, 224	2, 223
Power of motors	39, 938	51, 269
Number of workmen employed in the mines and works	158, 446	156, 197
Number of workmen employed in the gold-washings	67, 854	69, 186
Number of workmen employed in the salines, (approximated)	40, 000	40, 000
Total of workmen employed	266, 300	263, 383

CHAPTER VII.

GREAT BRITAIN.

PRINCIPAL EXHIBITORS; CAMMELL & CO.; JOHN BROWN & CO.; BOWLING IRON COMPANY; THOMAS FIRTH & SON'S STEEL INGOTS; LANDORE SIEMENS STEEL COMPANY; WHITWELL'S HOT-BLAST STOVES; SIEMENS'S DIRECT PROCESS; DECORATED TIN-PLATE.

152. The exhibition of iron and steel by Great Britain is meager compared with its rank as first on the list of iron-producing countries. There are but few exhibitors, and no effort appears to have been made to present a general or statistical view of the extent and value of British iron-industry, as was done at the Paris Exposition in 1867.

153. The annexed tables exhibit the exports of iron and steel from Great Britain for the years 1873 and 1874, and during the first half of the year 1875. These figures are compiled and published by the Board of Trade authorities, and are cited by Mr. Forbes in the report of the Iron and Steel Institute of Great Britain.

Exports of iron from Great Britain in the years 1873, 1874, *and the first half of* 1875.

Whither exported.	1873.	1874.	1875.
Pig:	*Tons.*	*Tons.*	*Tons.*
To Germany	146, 743	61, 820	106, 911
To Holland	189, 868	84, 546	95, 771
To Belgium	81, 317	40, 578	58, 074
To France	52, 353	26, 983	42, 184
To United States	63, 183	26, 760	26, 580
To British North America	18, 847	14, 958	22, 502
To other countries	82, 434	64, 253	80, 577
Total	634, 745	319, 898	432, 599
Bar, angle, bolt, and rod:			
To Russia	6, 533	6, 031	7, 395
To Germany	19, 203	3, 697	3, 618
To Holland	8, 303	2, 765	3, 689
To France	2, 142	369	286
To Italy	8, 395	8, 871	10, 551
To Turkey	3, 240	5, 853	5, 150
To United States	20, 535	3, 193	1, 380
To British North America	19, 205	12, 771	10, 143
To British India	7, 892	18, 224	25, 082
To Australia	7, 624	9, 003	15, 678
To other countries	47, 153	44, 708	45, 416
Total	150, 225	115, 485	128, 388
Railroad, of all sorts:			
To Russia	47, 780	74, 460	30, 927
To Sweden and Norway	15, 876	39, 968	25, 293
To Denmark	2, 808	5, 897	2, 063
To Germany	24, 375	3, 297	737
To Holland	8, 214	9, 004	3, 388
To Belgium	16, 843	12, 306	423
To France	2, 139	1, 613	51
To Spain and Canaries	6, 548	10, 985	6, 168
To Italy	13, 084	10, 254	5, 338
To Turkey	552	8, 889	28
To Egypt	1, 667	10, 930	1, 474
To United States	120, 468	64, 969	15, 734

Exports of iron from Great Britain, &c.—Continued.

Whither exported.	1875.	1874.	1873.
	Tons.	*Tons.*	*Tons.*
To Brazil	3, 963	11, 597	5, 059
To Peru	5, 467	4, 628	11, 455
To Chili	2, 908	9, 185	11, 045
To British North America	29, 774	28, 710	52, 790
To British India	8, 132	25, 026	16, 901
To Australia	9, 993	38, 088	42, 015
To other countries	27, 839	57, 461	28, 418
Total	348, 430	427, 267	259, 307
Wire of iron or steel, (except telegraph-wire,) galvanized or not	15, 992	14, 714	21, 960
Hoops, sheets, boiler and armor plates:			
To Russia	8, 520	3, 312	5, 247
To Germany	17, 213	2, 888	5, 850
To Holland	6, 282	3, 076	4, 827
To France	3, 375	714	803
To Spain and Canaries	2, 430	3, 481	2, 843
To Italy	4, 676	3, 638	4, 465
To United States	12, 935	2, 892	3, 313
To British North America	5, 742	3, 342	3, 168
To British India	6, 279	8, 857	16, 542
To Australia	10, 410	10, 605	17, 527
To other countries	30, 580	26, 004	30, 016
Total	108, 442	68, 809	94, 601
Tin plates:			
To France	2, 095	1, 236	1, 099
To United States	49, 645	49, 717	52, 323
To British North America	1, 619	952	1, 878
To Australia	2, 231	1, 839	1, 398
To other countries	11, 253	9, 790	15, 432
Total	66, 843	63, 534	72, 130
Cast or wrought, and all other manufactures (except ordnance) unenumerated:			
To Russia	21, 846	7, 405	8, 060
To Germany	18, 251	6, 245	8, 950
To Holland	8, 710	4, 120	4, 629
To France	2, 601	1, 813	2, 353
To Spain and Canaries	5, 098	5, 452	3, 326
To United States	7, 136	12, 008	4, 703
To Peru	4, 427	1, 463	758
To Brazil	6, 857	4, 268	3, 962
To British North America	8, 135	13, 031	8, 098
To British Possessions in South Africa	2, 604	2, 869	3, 065
To British India	9, 533	10, 462	14, 018
To Australia	14, 528	16, 708	21, 695
To other countries	30, 938	43, 808	34, 634
Total	140, 664	129, 652	118, 251
Steel, unwrought:			
To France	1, 478	1, 284	1, 355
To United States	10, 879	6, 520	5, 566
To other countries	8, 293	6, 443	7, 929
Total	20, 652	14, 247	14, 850
Old iron for remanufacture:			
To United States	26, 650	3, 586	3, 783
To other countries	14, 705	10, 967	5, 062
Total	41, 355	14, 553	8, 845
Manufactures of steel, or steel and iron combined	5, 314	4, 561	5, 949
Total of iron and steel	1, 532, 662	1, 172, 720	1, 156, 180

154. PRINCIPAL EXHIBITORS.—The heaviest exhibition in the British section is made by the firm of Cammell & Co., of Sheffield, which sends cast-steel propeller-blades, rails, wheels, axles, and armor-plates. The firm of John Brown & Co., which sent such massive iron plates to the

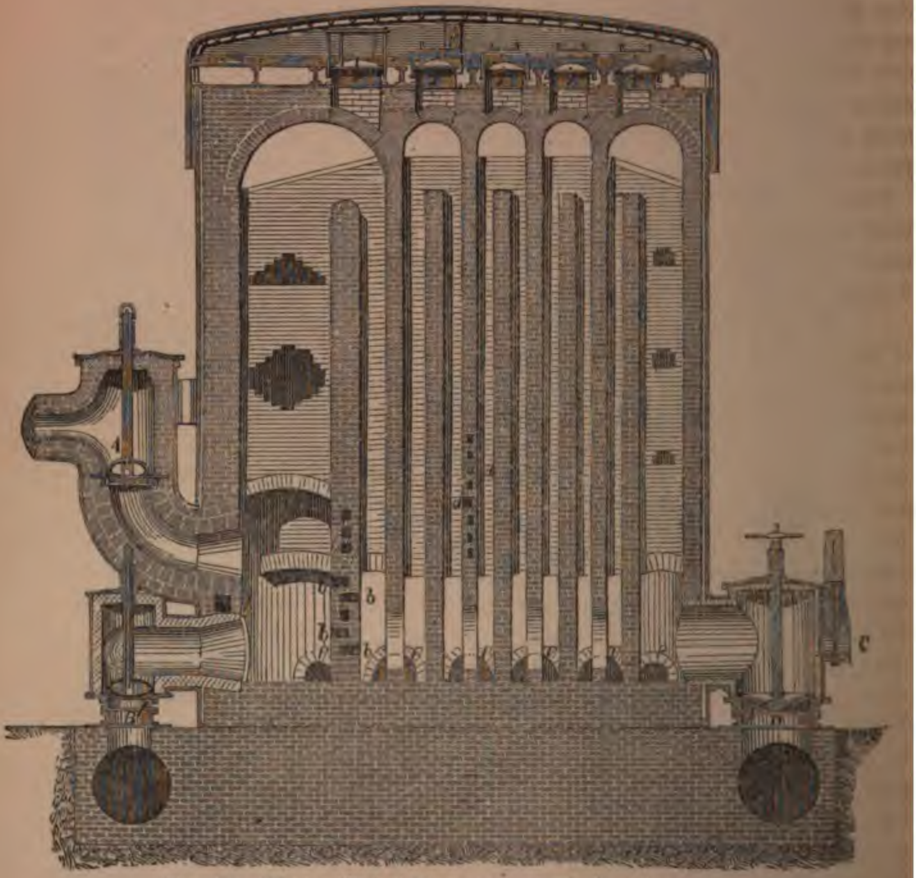


FIG. 61.—Whitwell's hot-blast stove, vertical section.

aris Exposition in 1867, is content this year with making a very full
splay of railway-material, and two small armor-plates showing the
fects of round shot and of pointed shot. The large plate sent by Cam-
ell & Co. is 20 feet long by 7 feet wide and 10 inches thick, and is
tended for the German turret-ship Borussia.

The Bowling Iron Company exhibits iron and steel boiler-plates, steel
stings, and railway-material. Steel tires for railway-wheels are shown
nt while cold into various forms without breaking. Thomas Firth &
n exhibit steel ingots; a homogeneous steel core for a 35-ton gun,
d forgings of the same metal for artillery and rifle barrels. The Lan-
re Siemens Steel Company send samples of their steel rail and tires,
d of the steel barrels for the Martini-Henry rifle. In the exhibition
ade by Johnson & Nephew, Manchester, there is a weldless wire 1,770
rds long.

There are several other contributions of considerable interest, but the
ost important in a metallurgical point of view are the exhibitions
ade by Thomas Whitwell of his hot-blast stoves, and by C. William
emens of a new process for the production of iron or steel.

155. WHITWELL'S HOT-BLAST STOVES.—The patent fire-brick stoves
Mr. Whitwell are intended to heat the blast of iron-furnaces. The
vention is represented by a very perfect model, accompanied by a full
ries of drawings, and, what is better, by an intelligent agent to explain
em. The stoves are designed to replace the ordinary iron pipes used for
eating the blast, substituting for them a series of fire-brick chambers
nd passages which are heated by the direct contact of the flames of the
urning gases taken from the furnace in the usual way. When the
ass of brick is sufficiently heated the gas is shut off and the blast is
dmitted. This in passing through the same heated chambers acquires
he temperature of the bricks. The brick-work, of course, gradually cools
own, but by the time the last chamber begins to be too cool another
tove has been heated up, and the blast is made to pass through that.
he stoves are thus alternately heated by the burning gas and cooled
y the blast. The advantages of this system are numerous. One of the
reatest is uniformity of temperature of blast, which cannot be counted
pon with iron pipes. The bricks are a great store-house of heat, and
ool gradually. Iron pipes cool suddenly when from any cause the sup-
ly of burning gas is stopped. The air being brought into direct contact
ith the surfaces previously heated by the gas, absorbs the heat quickly
nd with little loss. The apparatus is simple, is easily erected, and is
eing extensively introduced. For cupola-furnaces, making 600 tons
week, two stoves, 12 feet square by 21 feet high, and with 2,270 super-
cial square feet of heating-surface in each, are necessary.

The construction of these stoves is shown by the annexed figures, giv-
g vertical and horizontal sections and plans.

FIG. 61.—*Heating the stove—vertical section.*—The hot-blast valve A and
e cold-blast valve C being closed, the gas-valve B is opened, through

which the gas enters the stove, traverses up and down the spaces between the upright walls, and enters the chimney-flue by the valve D. Heated air is supplied to the gas by means of the air-valves *a* and *c* and passages *b* and *d*, by which a most intense combustion is gained. The internal heat of the stove, as well as the combustion of the gas, is observed by the eye-pieces *e e*.

FIGS. 61, 62.—*Heating the blast.*—The chimney-valve D and gas-valve B being closed, and the hot-blast valve A being opened, the cold blast is admitted through the cold-blast valve C and issues from the stove by the valve A *red hot*, all other valves being closed perfectly tight.

FIGS. 61, 63, 64.—*Cleaning the stove.*—When it is required to clean a stove the top cleaning-doors E are opened and the walls scraped with the "cleaning-tools," when the dust deposited on the heating-surfaces falls to the bottom of the stove, and is removed by the bottom cleaning-doors F.

The upper plan, page 230, shows the arrangement of the stoves to four furnaces *in full blast* at the Consett Iron-Works; but this plan may be varied to suit all circumstances.

The following distinguishing advantages are claimed by the inventor for these stoves:

1st. That they will stand a temperature of 2,000° without damage.

2d. There is no wear and tear of cast-iron pipes or material.

3d. They are sooner cleaned than any others, the time required between aying off and starting again being six hours. They are not cooled down, but are cleaned from the outside while red-hot. This takes place at intervals at from three to six months, according to the amount of dust in the gas.

4th. The principle on which the stoves are constructed insures the greatest economy of gas or fuel, whilst the heat that is obtained in the blast is nearly the whole of that given off by such gas or fuel.

5th. The cost of the stoves is not proportionately more per furnace than that of ordinary cast-iron plant, equal to modern requirements.

6th. These fire-brick stoves effect a saving of several cwts. of fuel per ton of iron made.

7th. The stoves being riveted and calked air-tight, there is no loss by bad joints, and hence a large amount of wear and tear is saved to the blowing engines.

8th. The areas throughout are so regulated that there is *no loss* of pressure by friction, but a pressure of four pounds in the engine-house gives *an equal pressure at the tuyere*, where the plans of the patentee are properly carried out.

9th. The immense reservoir of caloric stored up in these stoves, each red-hot wall acting as a fly-wheel so to speak, and giving out its power when most required, produces the best effect on the working of a furnace.

10th. These stoves form *a perfect regulator* to the blast, acting in th

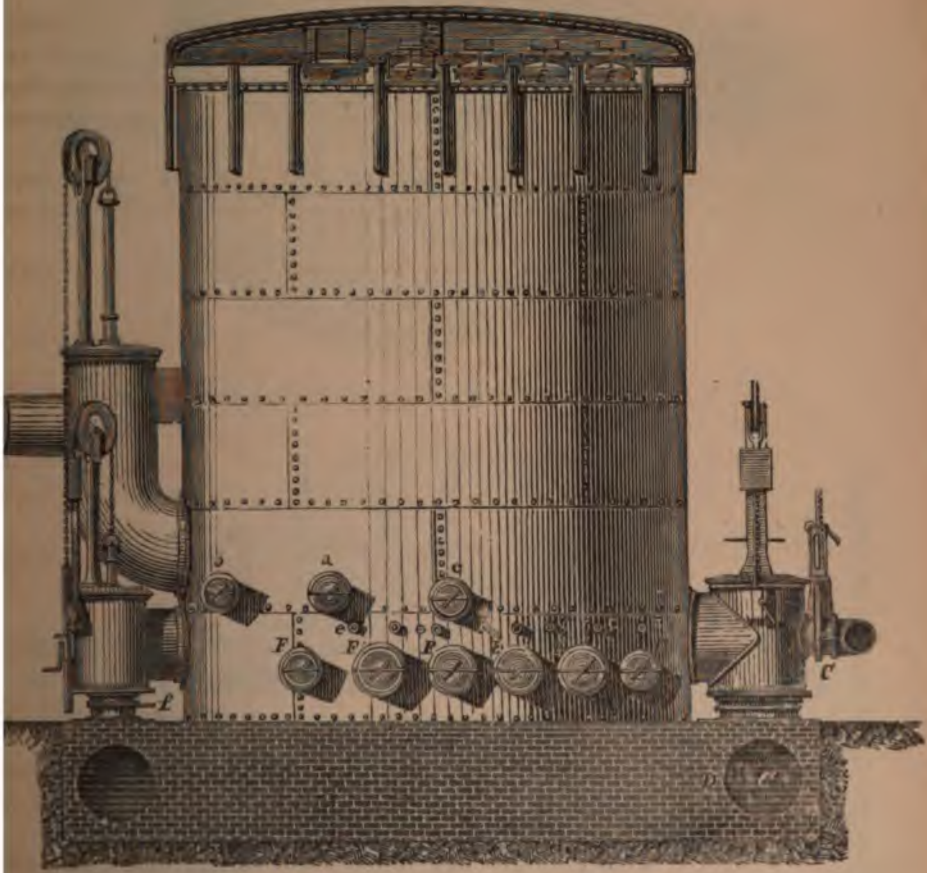


FIG. 62.—Whitwell's hot-blast stove, elevation.

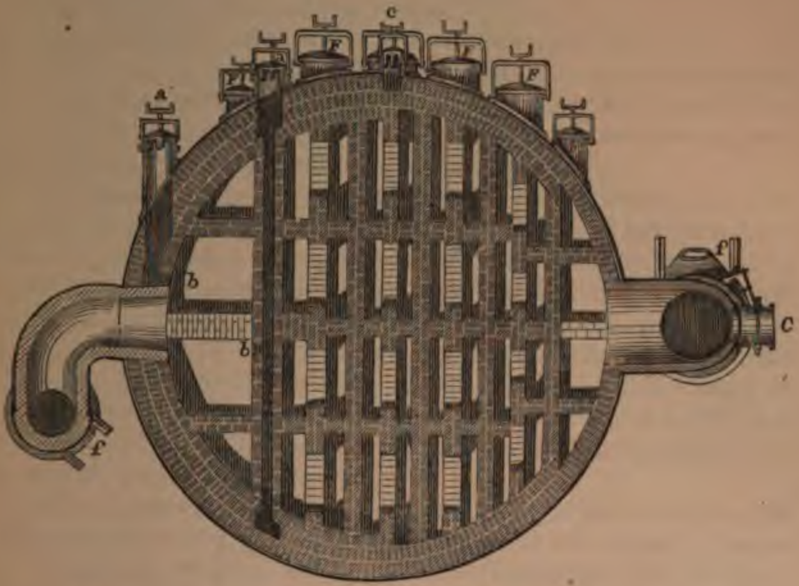


FIG. 63.—Whitwell's hot-blast stove, horizontal section.

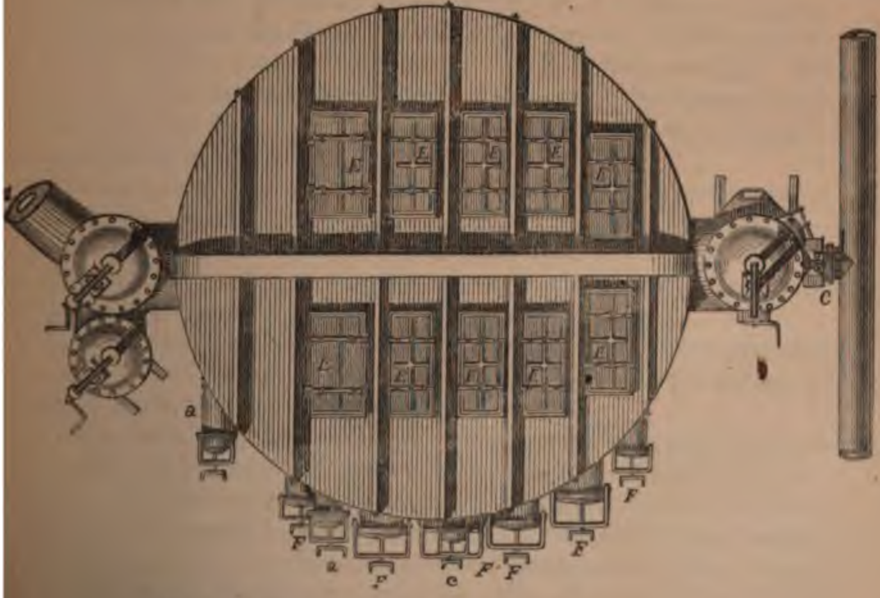


FIG. 64.—Whitwell's hot-blast stove, plan.

spect as the air-vessel in a force-pump, and dispensing altogether with e large air-regulators that are found necessary in many works, the ast being perfectly steady at the tuyere.

The use of hot blast, of the temperature obtainable from these fire-ick stoves, enables iron-masters to effect a saving in fuel, much beyond hat can be obtained by any amount of cast metal pipes; and, if a heat om 1,500 to 2,000 degrees and upwards be desired, these stoves stand without damage, whilst metal ones at once give way.

It is now generally known that *high* furnaces do not work well with any kinds of fuel and ores, where those of *moderate* dimensions have difficulty, but the hot blast produced by Whitwell's fire-brick stoves ever fails to effect the desired saving in fuel, whilst at the same time oving a corrective to nearly all those evils that lower the make and uality of pig-iron. In France, Alsace, Lorraine, the hematite districts, c., high furnaces have been already tried, but have failed chiefly on ccount of their scaffolding; the approved height of furnace is now from to 60 feet, except in Cleveland, whether for smelting hematite, mag-etic, oolitic, or carbonaceous ores.

The original patents of Messrs. Siemens & Cowper have now expired, nd therefore the extra royalties hitherto imposed are saved. Patents ave been granted to these stoves in Great Britain, France, Belgium, he United States, Luxembourg, Russia, Austria, Spain, Portugal, Swe-en, Norway, Italy, the East Indies, New Zealand, and Canada.

The celebrated firm of Messrs. *Schneider & Cie*, Le Creusot, France, ave during the past year blown in their first furnace on this system. hey make, with four stoves, 400 tons per week of Bessemer pig. *The owlais Iron Co.*, Merthyr Tydvil, have also adopted the stoves for the ame purpose, not only on account of the heat of the blast, but the *per-ect regularity* with which they work.

In general terms one stove will make 100 tons of pig per week; at the *onsett Works*, one stove makes above 125 tons *gray iron per week;* and or some time past, the furnaces on a mixture with 46 per cent. metallic ron have made, with four stoves, 500 tons per week; the average tem-erature of the blast is 1,400° by Siemens' pyrometer.

In Luxembourg, with oolitic ores of 32 per cent. metallic iron, and coke ith 18 per cent. of ash, the consumption is 20 cwt. coke per ton of ray pig; production 525 tons per week per furnace.

At Weilerbach, in a charcoal furnace 29 feet high, with oolitic ores of 2 per cent. metallic iron, the consumption is 20 cwt. charcoal per ton of ray pig; the adoption of fire-brick stoves in this case to an old furnace nabled the proprietors to use a mineral of *less value* producing the *same uality of pig as was formerly made with more expensive ores;* the economy n fuel attained by the fire-brick stoves is 6 cwt. charcoal per ton of pig, nd castings of the finest description are run direct from the blast fur-ace, the iron being now exceedingly soft.

Heating surface.—In these stoves *every square inch* is effective as heating surface, as ***the burning gases*** are compelled between entering and leaving the stove to traverse the ***whole surface of the bricks exposed;*** the blast in its turn also passes over the identical surfaces previously heated by the gas, and absorbs from them the heat required.

In no other stoves where brick-work is used as heating-surface is this the case; hence in Whitwell's fire-brick stoves a ***much smaller quantity*** of heating-surface is necessary for heating the blast, inasmuch as every part of it is effective.

At this date, the stoves are adopted by 33 firms, including some of the largest in Europe, *Consett*, *Dowlais*, *Le Creusot*, *De Wendel & Cie.*, *Krupp*, *Bochum*, *Dupont & Dreyfuss*, *&c.*

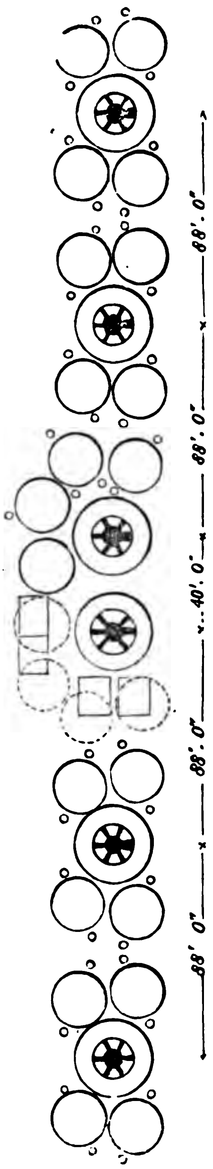
These hot blast fire-brick stoves have been adopted by the following firms:

	Furnaces.	Stoves.	
		Stoves building.	Stoves in blast.
GREAT BRITAIN.			
Consett Iron Company, limited, Durham	5	4	16
North of England Industrial Iron Company, limited, Carlton Iron Works, Stockton-on-Tees.	3	0	12
The Solway Hematite Iron Company, limited, Maryport. (Bessemer pig)	2	......	8
The Moss Bay Hematite Iron Company, Workington. (Bessemer pig)	3	8	4
The West Cumberland Hematite Iron Company, Workington	1	4	......
The Butterley Iron Company, Alfreton, Derby	1	2	......
The Tees Bridge Iron Company, limited, Stockton-on-Tees	2	6	4
Wm. Whitwell & Co., Thornaby Iron Works, Stockton-on-Tees	2	16	......
Bell Brothers, Walker Iron Works, Newcastle-on-Tyne	2	8	......
SOUTH WALES.			
The Dowlais Iron Company, Merthyr Tydvil	1	4	......
The Governor and Company of Copper Miners in England, Cwm Avon, Port Talbot	1	4	......
CONTINENT.			
FRANCE.			
M. M. Schneider & Cie., Le Creusot. (Bessemer pig)	1	......	4
Le Baron Adelsward, Longwy	1	4	......
Société de Vezin Aulnoye, Nancy	1	4	......
Société Anonyme des Forges de Denain	1	4	......
Société de Commentry et Chatillon	1	4	......
PRUSSIA.			
F. Krupp, Johanneshutte, Duisberg	1	4	......
Friederich-Wilhelms-Hütte, Mulheim, a. d. Ruhr	2	8	......
Société D'Acier Bochum, Westphalia	2	8	......
Société de Horde, Dortmund	1	4	......
J. H. Dressler, sen., Siegen	1	4	......
Schalker, Gruben & Hütten Verein, Gelsen-Korchen	2	8	......
Concordiahütte Eschweiler	1	4	......
ALSACE LORRAINE.			
M. M. Le Petit Fils de Fois, De Wendel & Cie., Hayange	2	8	......
M. M. Dupont & Dreyfuss, Ars-sur-Moselle	1	4	......
GRAND DUCHY OF LUXEMBOURG.			
Société Anonyme Des Hauts-Fourneaux, Esch-sur-L'Alzette	2	4	4
M. M. Philip & Bernard Serrais, Weilerbach. (Charcoal pig)	1	...	2
M. M. Metz & Cie., Forges d'Eich	1	2	......

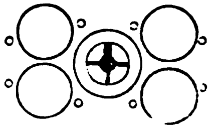
	Stoves.		
	Furnaces.	Stoves building.	Stoves in blast.
BELGIUM.			
Société Anonyme des Hauts Fourneaux, Athus	2	10	......
Société John Cockerill, Seraing, Liege	2	8	......
SPAIN.			
Cantabrian Iron Company, limited, Bilboa	2	6	......
UNITED STATES.			
Cedar Point Iron Company, Port Henry, New York	1	4	......
Boyle, Ditmans & Jarais, Rising Fawn, Georgia	1	3	......
Total	53	149	58

Total: 33 companies, 53 blast-furnaces, 207 stoves.

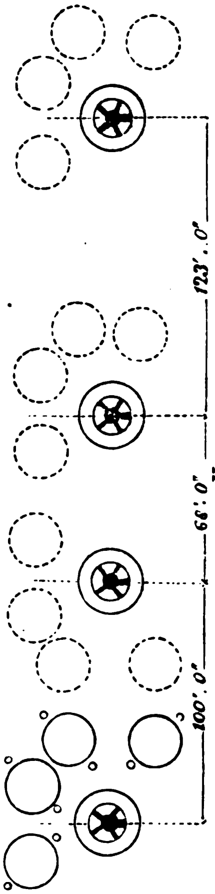
The arrangement of the stoves at Consett, at Krupp's, and at Creusot is shown in the annexed cut.



Arrangement of Whitwell's stoves—Consett.



Le Creusot.



Krupp.

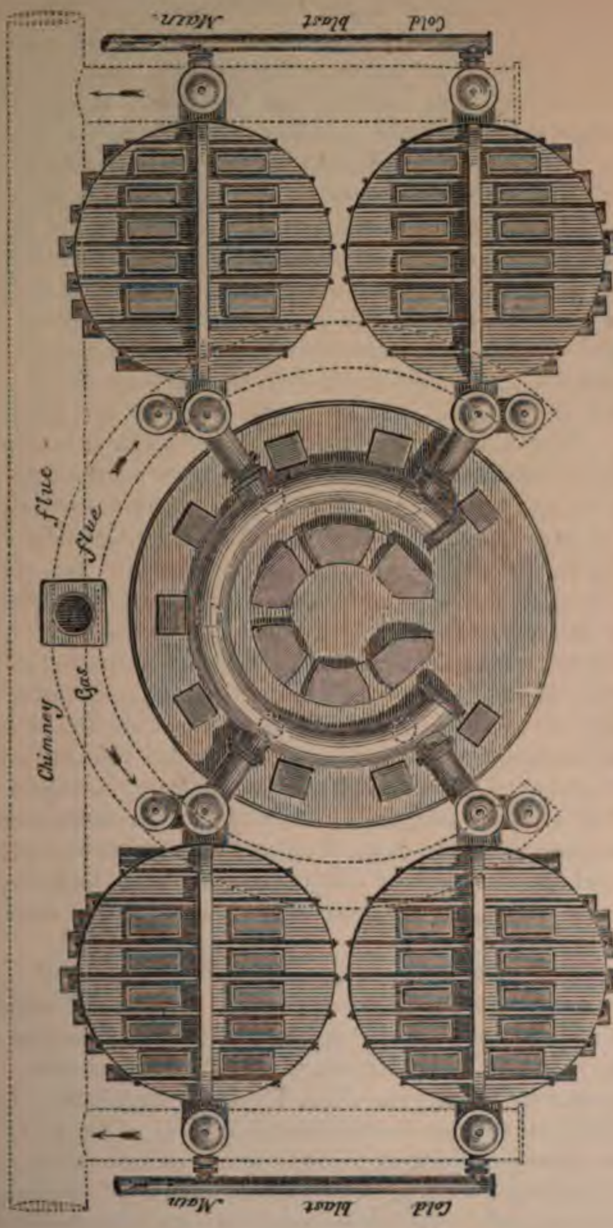


FIG. 63.—Plan of arrangement of Whitwell's stoves—Consett Works.

156. SIEMENS' DIRECT PROCESS.—Dr. C. William Siemens, of London, illustrates his newly-proposed method of producing iron and steel directly from the ore by models of the furnaces and apparatus, with specimens of the products and of the materials employed. The chemistry of iron metallurgy is indebted to Dr. Siemens for many valuable contributions, not the least of which is his lecture before the Chemical Society, in March last, upon smelting iron and steel. In that lecture he gave, in considerable detail, the course and results of the experiments which finally led him to adopt the direct process. Briefly stated, this process consists in smelting successive charges of ore in a rotary puddling furnace. A charge of about twenty hundred-weight of crushed ore mixed with the proper fluxing material is placed in the rotating puddler. When, by the flame from a regenerative furnace, it has been brought to a red heat, from five to six hundred-weight of small coal is added and the speed of the puddler is increased. The reduction of the ore to the metallic state proceeds rapidly, the carbonic oxide evolved is burned within the chamber, and very little gas from the gas-producers is required. When the reduction is complete the puddler is stopped, and the fluid slag is drawn off. The puddler is then rotated rapidly; the iron is collected into two or three metallic balls, which are withdrawn and treated in the usual way. About two hours are required for a charge, and assuming that one thousand pounds of iron are got out to each charge, the furnace would produce about five tons of puddled bar per diem. It is claimed to be feasible to push the operation so far within the rotator as to produce cast-steel. Mr. Siemens claims and undertakes to demonstrate that by this process a very great saving of fuel is effected. For the lining of the rotary puddler, after numerous trials, he has found a mixture of calcined bauxite powder with clay and plumbago to be the best. Three per cent. of clay and six per cent. of plumbago give the best results as binding materials. Bauxite is a ferruginous clay, containing from one to four per cent. of silica. The graphite, under the intense heat, reduces the oxide of iron in the bauxite to the metallic state. Linings so made have been found to be very durable, far more so than the best fire-brick.

As Dr. Siemens' papers have been extensively published and circulated,* it is unnecessary to give more than this general notice of his process. Experiments are yet in progress at his experimental works in Birmingham, to which a special visit was made by the writer.

157. DECORATED TIN-PLATE.—The Tin-Plate Decorating Company, of Neath, England, made a considerable display of tin-plate covered with a great variety of designs and of various colors. Such plates are supplied of any required design, at only a moderate increase of cost over ordinary tin-plate. They are already largely introduced for small boxes and cases for medicines, matches, spices, and the like. It is claimed by the manufacturers that the colors are indelibly printed by a

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* See Jour. of the Iron and Steel Institute, 1873, i, p. 37.

patented process, and that they can be varied at pleasure, will resist the action of boiling acid, and are neither affected by heat nor cold.

For small parcels decorated plates possess the advantage of being cheaper than the ordinary paper-labeled canister, and goods so packed are preferred by dealers, as the covering is not liable to damage from either dust or damp; the empty package, moreover, presents a perpetual advertisement of its former contents.

For show-cards this article is particularly adapted, as the covering will resist the weather and they can be produced at a lower cost than the card-board designs in ordinary use, the expense of glass and framing and the risk of breaking or damage being entirely avoided.

CHAPTER VIII.

UNITED STATES.

REPRESENTATION AT THE EXHIBITION NOT THOROUGH; LAKE SUPERIOR ORES; PRODUCTION OF THE LAKE SUPERIOR REGION; EXHIBITION OF CAST-STEEL BY PARK BROTHER & CO.; IRON-ORES OF ESSEX COUNTY, NEW YORK; ORES FROM PENNSYLVANIA, INDIANA, AND ALABAMA; ROTHWELL'S WYOMING MAP; SELLERS' PUDDLING-MACHINE; SELLERS' HIGH ROLLS; PRODUCTION OF PIG-IRON IN THE UNITED STATES; ROLLED IRON; PRODUCTION OF RAILS AND OF BESSEMER AND OTHER KINDS OF STEEL; STATISTICAL TABLES OF PRODUCTION IN THE UNITED STATES.

158. There are a few specimens of American iron-ores at the Exhibition, enough to direct attention to the fact that we are an iron-producing country, but the exhibition is by no means commensurate with our wealth and production of iron and of steel. There are withal no statistics, in a presentable form; nothing to satisfy the desire of inquirers concerning the extent and distribution of the iron and the coal of the country. The catalogue is equally barren. There does not appear to be a specimen of Bessemer or Martin's steel from the United States; and a stranger to our metallurgical industries, judging of the country by what he finds in the Exhibition, would infer that such advanced methods of producing steel are not yet introduced. But there is one exception, of crucible steel; the Messrs. Park, Brother & Co., of Pittsburgh, have sent a few samples and a very fine specimen of hot flanging for a boiler-head, which attracted the attention of the jury and received a medal.

159. LAKE SUPERIOR ORES.—Mr. George R. Tuttle, of Cleveland, Ohio, forwarded a very good series of blocks of the magnetic and specular ores of the Lake Superior region, as received by water-transportation at Cleveland from Marquette. The size and evident purity of these specimens attracted attention. This exhibition would be much more instructive if accompanied by photographs or models of the mines and statistics of the production. The production, which was some 7,000 tons in the year 1856, increased to over a million of tons in the year 1873.

The following is a list of the chief iron mines upon Lake Superior, with the production in the year 1874, compiled by the editor of the *Marquette Mining Journal*, and cited by the secretary of the American Iron and Steel Association:

Production of Lake Superior Mines, 1874.

Mine.	Tons.	Mine.	Tons.
Jackson	105,600	Winthrop	8,242
New York	77,010	Shenango	7,549
Cleveland	108,580	Saginaw	45,486
Lake Superior	114,074	Carr	948
Champion	46,769	Bagaley	541
Washington	28,390	Howell Hoppock	966
Republic	126,956	Emma	726
Kloman	35,088	Goodrich	3,100
Cascade	16,931	Home	2,139
Barnum	41,403	Rolling Mill	16,643
Foster	3,318	Teal Lake	2,610
Salisbury	7,480	Excelsior	1,065
Lake Angeline	31,526	Williams	593
Pittsburgh and Lake Superior	1,362	Allen	130
Edwards	2,849	Stewart	305
Spurr Mountain	42,068	Gilmore	162
Michigamme	45,294	Miller	1,717
Keystone	5,227		
McComber	2,641	Total	935,488

The decrease in the shipments of 1874, as compared with the shipments of 1873, was 231,891 tons, the production of the year last named being 1,167,379 tons. The product of 1874 was almost as large as that of 1872, which was 952,055 tons. Below is a table showing the aggregate yield of all the mines from 1856 to 1874:

1856	7,000	1867	466,076
1857	21,000	1868	507,813
1858	31,035	1869	633,238
1859	65,679	1870	856,471
1860	116,908	1871	813,379
1861	45,430	1872	952,055
1862	115,721	1873	1,167,379
1863	185,257	1874	935,488
1864	235,123		
1865	196,256		
1866	296,972	Total	7,648,280

In the year 1873, the price of Lake Superior ores at Cleveland was about $12 before the monetary panic, and $10 after it. In 1874 the price receded to about $9, and then to $7 and $7.50.

160. CAST STEEL OF PARK, BROTHER & CO.—The samples of crucible-steel boiler-plate, sent by Messrs. Park, Brother & Co., were manufactured by them at their establishment, known as the "Black Diamond Steel Works," in Pittsburgh, Pa.

The exhibition is confined to several specimens of homogeneous steel boiler-plate, showing the strength, ductility, and flanging capacity of the metal. This class of material produced in these works has already been used, to some extent, on European railways, and by other railways abroad supplied with American locomotive engines, in the construction of which the "Black Diamond" steel has been used.

This firm of Park, Brother & Co. was organized early in the year 1862, and the erection of the works was commenced immediately thereafter. Their business is the manufacture of all descriptions of bar, plate, and sheet cast-steel, and, in addition, the German or "converted steel." The process of manufacture originally adopted is that which is still in operation—the "cementation process." In the production of cast-steel at these works neither the Bessemer, "Siemens-Martin," or other kindred methods have been used, their operations having been confined exclusively to crucible melting.

Among the many grades of steel produced the following may be enumerated: Best cast-steel, for machinists' and edge tools, for mining-drills, dies, &c.; steel suitable for reaping and mowing machines, plows, cultivators, and other agricultural implements; homogeneous steel-plates for locomotive, stationary, and marine steam-boilers; steel for cotton, woolen, and other machinery, together with grades suitable for the manufacture of files, cutlery, springs, saws, &c.

The leading specialties of this establishment are best cast-steel homogeneous plates, file-steel, sheet cast-steel for reaper and mower knives, together with certain other grades for various purposes.

The establishment is one of the largest in the steel trade of this country, occupying several acres of land, and possessing extensive mechanical appliances for the effective prosecution of their extensive and increasing business.

The average number of men directly employed is 400, and the productive capacity of the works is 10,000 tons annually. The manufacture in the United States of the highest grades of cast-steel is claimed to have been first fully developed in these works.

The firm has participated with advantage in most of the great exhibitions. It received a gratifying award at Paris in 1867. They have exhibited at London, Boston, Cincinnati, New Orleans, and other cities, receiving in the aggregate ten or twelve medals. At this Vienna exhibition the jury has decreed a medal.

161. IRON ORES OF ESSEX COUNTY, NEW YORK.—The rich magnetic iron-ores of the northern part of the State of New York are represented by specimens sent by Messrs. Witherbee & Sherman from Port Henry, on Lake Champlain. Among the specimens there are several fine octahedral crystals of magnetite from the "New Bed," so called; masses from the old Sanford ore-bed, and from other beds tributary to the manufacture of iron at Port Henry. No statistics given.

C. S. Johnston, of New York City, contributes a well-prepared series of specimens of the ores of the Clifton Iron Mine collected by Professor Silliman at the locality. They are accompanied by samples of the flux, the pig-metal, and small blooms, and by a short description in print giving the results of analyses. From this description it appears that the property of this company consists of three-quarters of the town of Clifton, Saint Lawrence County, New York, and embraces about 23,000 acres of land, most of it densely wooded, through which the Grass River flows about nine miles, affording numerous and unfailing water-powers of from 10 to 35 feet fall.

The greater portion of the wood on the entire tract is hard, composed of beech, maple, birch, and cherry, interspersed with pine, spruce, tamarack, hemlock, ash, and cedar.

The mines include several extensive deposits of magnetic ores, lying mainly above water-level. At the principal bed the veins have been opened at several points, and about 15,000 tons of ore taken therefrom have been converted into neutral iron, and used for admixture with "red short" ores, with very satisfactory results.

The ores are said to yield from 50 to 65 per cent. of iron of remarkable tenacity and specially adapted for wire and crucible steel and for foundery purposes. Their purity and general characteristics are shown by the following analyses of average samples by Professor Chandler, of the Columbia College School of Mines, New York, October, 1872:

The samples of magnetic iron-ore from Prof. B. Silliman, marked "All parts Whim shaft, Arendal vein," submitted to me for examination, contain—

Magnetic oxide of iron	79.29
Oxide of manganese	0.35
Alumina	3.45
Lime	4.46
Magnesia	3.09
Sulphur	0.35
Phosphoric acid	0.32
Silicic acid	8.32
Water	0.51
	100.14

Equivalent to—

Metallic iron	57.42
Metallic manganese	0.23
Phosphorus	0.14
Sulphur	0.35

No. 7, MAGNETIC, (above lower tunnel.)

Magnetic oxide of iron	80.91
Oxide of manganese	0.42
Sulphur	0.08
Phosphoric acid	0.03
Silicic acid	8.77

Equivalent to—

Metallic iron	58.59
Metallic manganese	0.29
Phosphorus	0.01
Sulphur	0.08

Tooley Lake, (new discovery.)

Magnetic oxide of iron	75.01
Oxide of manganese	0.42
Sulphur	0.08
Phosphoric acid	0.03
Silicic acid	13.34
Equivalent to—	
Metallic iron	54.32
Metallic manganese	0.29
Phosphorus	0.01
Sulphur	0.08

Sheridan Vein, (new discovery.)

Magnetic oxide of iron	79.83
Oxide of manganese	0.72
Sulphur	0.41
Phosphoric acid	trace.
Silicic acid	8.55
Equivalent to—	
Metallic iron	57.81
Metallic manganese	0.50
Phosphorus	trace.
Sulphur	0.41

A good wagon-road about twenty-two miles long leads from the property to De Kalb Junction, on the Rome, Watertown and Ogdensburg Railroad, nineteen miles from Ogdensburg. A nearer route to Ogdensburg is projected.

162. Ores from Pennsylvania, Indiana, and Alabama.—E. C. Pechin, esq., of the Dunbar furnace, Fayette County, Pennsylvania, sends a neatly arranged collection of the ores, coal, coke, and iron. The specimens are placed in a box with partitions, and the description of the specimens is added in gilded letters.

There are also specimens of Connelsville coke and coal, sent by Prof. Amasa McCoy and Philo Norton.

Prof. E. C. Cox, the State geologist of Indiana, makes a fine display of "block-coal," of iron-ore, and of pig-iron, all from the southern part of the State.

Colonel Wilder, of Chattanooga, Tenn., arrived late with an enormous block of iron-ore, large blocks of coal, blooms, pig-iron, bar-iron, &c. This collection made a fine display, and was honored by a medal.

163. Rothwell's Wyoming Map.—The iron resources of Alabama are merely indicated by a few small specimens. This is also the case with North Carolina and a few other States. Mr. R. P. Rothwell forwarded some of the Alabama ores, and also contributed one of his large maps of the Wyoming anthracite coal-fields. This map, which required years of patient labor, was presented, at the close of the Exhibition, to the engineer department of Belgium.

164. **SELLERS' PUDDLING-MACHINE.**—The rotatory puddler exhibited y Mr. William Sellers, of Philadelphia, has, from the first, attracted reat attention. The novelty of its form, the single opening in front, s compactness and finish, and the ease with which it is manipulated,

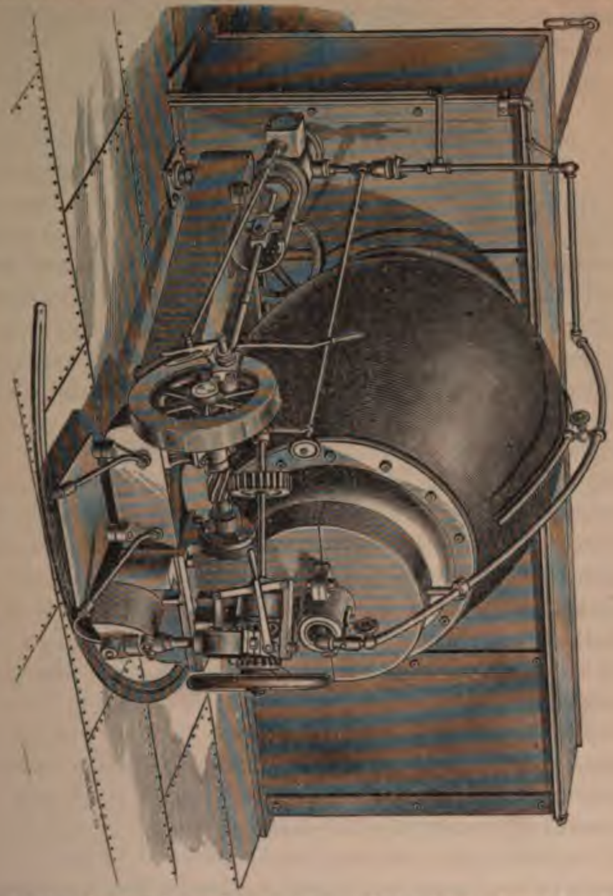

FIG. 64.—SELLERS'S ROTARY PUDDLER.

ll commend it to the notice of iron-men. It is flask-shaped. The flame asses in, circulates, and passes out again at the same end by which entered, on the opposite side of a horizontal partition which divides e opening. All the other rotatory puddlers have openings at the op-ite ends, one of which is closed by a sliding-door, and is used for harging and discharging. The puddler is so placed upon a frame at it can be swung away from the furnace to permit of charging from e front. The parts most exposed to the heat are protected on the utside by water-jackets. The charges for this puddler are to be melted an auxiliary furnace, saving not only the lining of the puddler, but me and fuel.

In detail, Mr. William Sellers's rotary puddling-machine, which was hown in full size and in motion, consists primarily of a cast-iron sphe-idal vessel, or furnace, rotating about its longer axis, which is supported in a horizontal plane. It is closed, at one end, by a water-back, and is open at the other for the reception of the charge of metal, and for the admission of the gases in combustion.

This puddling "bowl," as it is termed, is mounted on a cast-iron frame or carriage, which also supports the steam-engine that drives the machinery to rotate the bowl and to move the frame about its axis. The frame is supported on three points; a pintle or hinge, and two wheels placed with their axes radial to the pintle. The bowl of the puddling-machine, when working, has its open end in contact with an opening of similar size in the front plate of a stack of flues. This opening, when exposed to view, shows the mouths of a number of flues; the upper ones conveying the gas and heated air to the bowl, while a larger opening below—the "down take"—carries off the products of combustion, and leads them to the "regenerative" system below the floor. At the mouths of the upper flues the air and gases mingle together, and, when ignited, enter the bowl, are driven to its back end, there reverberating, pass over its lower half, and escape through the "down-take," thus filling the bowl with an intensely hot flame.

The bowl is lined or fettled with lumps of refractory iron-ore, built in, like rough stone-work, with some quick-setting cement.

The "water-back," which forms one end of the bowl, has a projecting journal resting in a bearing, while the other end of the bowl is supported on friction-rollers in the frame.

The journal on the water-back is hollow, and through it passes a pipe, having one end (that within the water-back) turned up in a nozzle, from which the water in escaping is thrown in a jet against the upper surface of the water-back, and, filling its lower half, flows out through the hollow journal into a water-pan, and is from thence carried away in pipes. The lower half of the water-back being always filled with water, during each rotation of the bowl all parts of the iron back are, in turn, immersed, and thus kept cool. The exterior surface of the bowl is cooled by jets of water falling from a sprinkler placed over it.

An engine on one side of the frame turns a worm or tangent wheel, which gears into a worm-wheel attached to the water-back, and serves to rotate the bowl.

A spiral pinion on the engine-shaft drives a train of wheels which imparts motion, in either direction, to one of the supporting-wheels, upon which the frame moves. By means of this connection the frame can be made to turn about the fixed pintle, like a door on its hinges, alternately closing the flue-openings with the mouth of the bowl, or exposing them to view when it is drawn away from the stack.

When open, or away from the stack, the interior of the bowl is accessible from its open end for repairs or inspection, for the introduction of the charge of metal, or for the removal of the puddled ball. When closed it is in position to receive the burning gas as it escapes from the flues. To prevent the stack of flues from cooling during the charging of the bowl, a circular, concave lid, lined with fire-brick and hung conveniently to a crane, is swung against the aperture in the iron plate on the stack usually covered by the bowl.

The cylinder of the operating steam-engine is immediately over the pintle about which the frame turns. The various pipes for water and steam are all connected with one stand, and are jointed in line with the center of the pintle, and provided with proper stuffing-boxes to permit them to turn with ease.

A platform at the back of the frame is provided for the engine-man. Standing on this he has within easy reach the throttle-valve, a friction-brake, (for sudden stopping,) a lever to operate the opening and closing attachments, and, also, a reversing-lever, enabling the engine to run backward or forward. A balance-wheel is provided to open and close the mouth of the bowl by hand.

The flue-stack against which the puddler-bowl closes is merely a rectangular iron casing, within which are constructed the various flues required for the heated air, the gas, and the down-take to the regenerator. A door at the back of the flue-stack can be opened for the ready inspection of the interior of the bowl while it is at work and under heat. In practice the charge having been introduced into the puddler, and its mouth brought up to the flue-stack, the ignited gas and air are admitted, and burning within the rotating-bowl, act upon the molten metal lying in the bottom of the bowl. The rotation stirs up the metal, which, boiling, "comes to nature," and is aggregated by the tumbling together of the particles of wrought iron. After this the surplus cinder can be drawn off through a tap-hole. The bowl being then turned away from the flues, the puddled ball can be readily taken out and carried to the squeezer or hammer.

If the iron be charged as pig, the bowl is not rotated until the metal has melted; but if the charge is drawn melted from a cupola, puddling may begin as soon as the bowl is brought up against the stack and the gases are admitted.

The international jury awarded a Medal of Merit.

165. SELLERS'S HIGH ROLLS.—A set of high rolls from the same establishment also deserves special mention. By a simple hydraulic arrangement these rolls can be set instantly at any required distance apart. A man, at one point, by a lever, controls the movement. Perfect parallelism is maintained and, in case of clogging, the rolls can be separated without accident.

IRON-PRODUCTION OF THE UNITED STATES.

166. PRODUCTION OF PIG AND ROLLED IRON.—In concluding this brief notice of the objects from the United States at Vienna, it is deemed advisable to supplement it by a brief statement of the iron-industry of the country at that period. The growth of the pig-iron branch of the iron-trade from 1854 to 1874 is shown by the following table, supplied

to the author by Mr. Swank, who has compiled it from statistics procured by the American Iron and Steel Association.*

Production of pig-iron in the United States, in net tons.

Years.	Anthracite.	Charcoal.	Bituminous coal and coke.	Total.
1854	339, 435	342, 298	54, 485	736, 218
1855	381, 886	339, 922	62, 390	784, 178
1856	443, 113	270, 470	69, 554	883, 137
1857	390, 385	330, 321	77, 451	798, 157
1858	361, 430	285, 313	58, 351	705, 094
1859	471, 745	284, 041	84, 841	840, 627
1860	519, 211	278, 331	122, 228	919, 770
1861	409, 229	195, 278	127, 037	731, 544
1862	470, 315	186, 660	130, 687	787, 662
1863	577, 638	212, 005	157, 961	947, 604
1864	684, 018	241, 853	210, 125	1, 135, 996
1865	479, 558	262, 342	189, 682	931, 582
1866	749, 367	332, 580	268, 396	1, 350, 343
1867	798, 638	344, 341	318, 647	1, 461, 626
1868	893, 000	370, 000	340, 000	1, 603, 000
1869	971, 150	392, 150	553, 341	1, 916, 641
1870	930, 000	365, 000	570, 000	1, 865, 000
1871	956, 608	385, 000	570, 000	1, 912, 608
1872	1, 369, 812	500, 587	984, 159	2, 854, 558
1873	1, 312, 754	577, 620	977, 904	2, 868, 278
1874	1, 202, 144	576, 557	910, 712	2, 689, 413

The following tables, from the same source, present a general view of the production of all forms of rolled iron in the country during the year 1874, the production of rails and of Bessemer steel. In the table of rolled iron all forgings, such as anchors, anvils, hammered axles, cranks, ships' knees, &c., are carefully excluded, owing to the difficulty of getting exact returns.

Production of rolled iron, 1874.

States.	Bar, angle, bolt, rod, and hoop iron.	Plate and sheet iron.	Cut-nails and spikes.	Iron and steel rails, all sizes.	Total rolled iron.
Maine	3, 994	....	....	14, 650	18, 644
New Hampshire	300	....	....	....	300
Vermont	....	....	....	10, 400	10, 400
Massachusetts	40, 324	6, 592	28, 819	24, 765	100, 500
Rhode Island	7, 170	....	3, 446	....	10, 616
Connecticut	11, 921	....	....	....	11, 921
New York	76, 590	4, 000	5, 949	46, 979	133, 518
New Jersey	24, 645	2, 256	27, 643	3, 537	58, 081
Pennsylvania	343, 632	120, 098	75, 151	259, 288	798, 169
Delaware	6, 860	4, 958	....	....	11, 818
Maryland	8, 455	12, 428	....	48, 008	68, 891
Virginia	11, 086	....	5, 602	....	16, 688
Georgia	1, 406	....	....	8, 061	9, 467
Alabama	1, 000	....	....	....	1, 000
West Virginia	1, 609	....	54, 201	522	56, 332
Kentucky	18, 239	5, 120	5, 121	6, 068	34, 548
Tennessee	1, 573	....	660	13, 693	15, 926
Ohio	105, 413	5, 143	27, 253	82, 561	220, 370
Indiana	7, 376	....	7, 514	20, 617	35, 507
Illinois	2, 500	2, 240	4, 250	125, 103	134, 093
Michigan	4, 207	1, 553	....	2, 448	8, 208
Wisconsin	275	....	....	29, 680	29, 955
Missouri	1, 500	10, 870	....	24, 017	36, 387
California	9, 205	....	....	7, 016	16, 221
Kansas	....	....	....	2, 000	2, 000
Total	689, 280	175, 258	245, 609	729, 413	1, 839, 560

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*Vide report of the secretary of the American Iron and Steel Association, January 1, 1875.

Secretary Swank states: "The total production of all rolled iron in 1874, Bessemer steel rails included, was 1,839,560 net tons, against 1,966,445 tons in 1873, a decrease of only 126,885 tons. This decrease was all in rails. Of the total product of the rolling-mills in 1874, 1,110,147 tons were rolled iron other than rails, against 1,076,368 tons in 1873, an increase of 33,779 tons. The number of tons of nail-plate consumed in 1874 was 245,609 net tons, against 201,235 tons in 1873, an increase of 44,374 tons. The increase of 33,779 tons in the aggregate production of rolled iron other than rails in 1874 was, therefore, wholly in the department of cut-nails and spikes. The total number of cut-nails and spikes produced in 1874 was 4,912,180, against 4,024,704 kegs in 1873."

In the production of rails the State of Pennsylvania takes the lead, but in a rapidly diminishing degree from year to year since 1871.

Production of rails by States, in tons.

States.	1871.	1872.	1873.	1874.
Pennsylvania	335, 604	419, 529	328, 522	259, 288
Illinois	91, 178	106, 916	136, 102	125, 103
Ohio	75, 782	121, 923	130, 326	82, 561
New York	87, 022	82, 457	59, 764	46, 970
Maryland	44, 941	26, 472	42, 356	48, 008
Wisconsin	28, 774	37, 284	39, 495	29, 680
Massachusetts	28, 864	29, 242	34, 034	24, 765
Indiana	12, 778	23, 893	26, 579	20, 617
Maine	13, 383	14, 058	16, 500	14, 650
Missouri	8, 200	15, 500	14, 020	24, 017
Tennessee	9, 667	14, 620	13, 973	13, 693
New Jersey	6, 700	9, 185	13, 749	3, 537
Kentucky	6, 000	4, 000	11, 386	6, 068
Georgia	7, 840	6, 930	8, 275	8, 061
Michigan	14, 000	9, 883	4, 433	2, 448
West Virginia	5, 000	20, 100	4, 000	522
Vermont	....	....	6, 088	10, 400
California	....	....	475	7, 016
Kansas	....	....	....	2, 000
	775, 733	941, 992	890, 077	729, 413
Street, mine, and light rails	....	58, 008	....	....
Total	775, 733	1, 000, 000	890, 077	729, 413

In 1874 there were eight completed Bessemer steel establishments, and the combined product of steel rails exceeded that of 1873, being 144,944 net tons in 1874 against 129,015 net tons in 1873.

Product of Bessemer steel rails, 1867 *to* 1874.

1867	2, 550	1871	38, 250
1868	7, 225	1872	94, 070
1869	9, 650	1873	129, 015
1870	34, 000	1874	144, 944

The annual production of merchantable Bessemer steel, for all purposes, is as follows:

1867	3, 000	1871	45, 000
1868	8, 500	1872	110, 500
1869	12, 000	1873	157, 000
1870	40, 000	1874	176, 579

There were forty-two establishments in the year 1874 producing other kinds of steel than Bessemer, including cast, puddled, blister, and open-hearth steel. The production of the latter is steadily increasing, amounting in 1874 to 7,000 tons, against 3,500 tons in 1873, and 3,000 tons in 1872. The total production of crucible-steel in the United States in 1874 is stated approximately as 34,128 tons, and of puddled, open-hearth, and blister steel as 13,353 tons.

Production of pig-iron in 1872, 1873, *and* 1874, *by States.*

States.	No. of stacks in blast Dec. 31, 1874.	No. of stacks out of blast Dec. 31, 1874.	No. of stacks blown out in Jan., 1875.	Whole No. completed stacks Dec. 31, 1874.	Whole No. completed stacks Dec. 31, 1873.	No. of new stacks completed in 1874.	No. of new stacks completed in 1873.	No. of new stacks completed in 1872.	No. of stacks building in 1875.	No. of stacks projected in 1875.	Make of pig-iron in 1872, net tons.	Make of pig-iron in 1873, net tons.	Make of pig-iron in 1874, net tons.
Maine	1	....	....	1	1	....	....	....	....	....	....	780	1,661
Vermont	2	....	....	2	2	....	....	....	....	....	2,000	3,100	3,450
Massachusetts	5	1	1	6	6	....	....	....	....	....	17,070	21,136	27,991
Connecticut	3	7	....	10	10	....	....	....	....	....	22,700	26,977	14,518
New York	37	21	7	58	53	5	4	2	2	2	291,155	296,818	326,721
New Jersey	10	7	....	17	16	1	1	2	3	2	103,858	102,341	90,150
Pennsylvania	142	124	15	266	162	4	14	19	19	17	1,401,497	1,389,573	1,213,133
Maryland	13	10	2	23	22	1	....	....	....	2	63,031	55,986	54,256
Virginia	15	23	4	38	35	3	3	2	2	2	21,445	26,475	29,431
North Carolina	2	6	....	8	8	....	1	....	2	2	1,073	1,432	1,340
South Carolina	....	8	....	8	8	....	....	....	....	....	....	....	....
Georgia	4	6	....	10	8	2	2	....	3	2	2,945	7,501	9,786
Alabama	6	8	1	14	11	3	3	....	2	3	12,512	22,283	32,863
Texas	....	1	....	1	1	....	....	....	....	1	629	280	1,012
West Virginia	5	4	....	9	6	3	1	1	2	....	20,796	23,056	30,134
Kentucky	11	16	7	27	25	2	....	....	....	2	67,396	69,889	61,227
Tennessee	13	9	6	22	20	2	1	1	1	6	42,454	43,134	48,770
Ohio	59	34	17	93	88	6	5	6	6	8	399,743	406,029	425,001
Indiana	3	5	....	8	8	....	....	2	....	1	39,221	32,486	13,722
Illinois	3	7	....	10	10	....	2	....	2	1	78,627	55,796	37,946
Michigan	16	18	2	34	33	1	6	4	....	6	100,222	123,506	136,882
Wisconsin	5	9	....	14	13	1	3	1	....	....	65,036	74,148	50,794
Minnesota	....	1	....	1	....	1	....	....	....	....	....	....	....
Missouri	8	11	....	19	18	2	4	1	1	5	101,158	85,552	75,817
Oregon	1	....	....	1	1	....	....	....	....	1	....	....	2,500
Utah	1	....	....	1	....	1	....	....	1	....	....	....	200
Total	365	336	62	*701	665	38	50	41	46	63	2,854,558	2,868,278	2,689,413

* Two furnaces, not included here, were abandoned in 1874; one in Ohio, and one in Missouri.

PEAT AND CHARCOAL.

Michigan	....	1	....	1	1	....	....	1	....	....	224	500	....

ANTHRACITE.

Massachusetts	1	....	....	1	1	....	....	....	....	....	4,250	5,432	10,214
New York	28	13	3	41	36	5	2	1	2	2	271,343	267,489	298,628
New Jersey	10	7	....	17	16	1	1	2	3	2	103,858	102,341	90,150
Pennsylvania:													
Lehigh	29	18	....	47	47	...	3	3	6	....	449,663	389,969	316,798
Schuylkill	30	13	4	43	40	3	3	3	5	3	232,225	236,409	232,[illegible]
Upper Susquehanna	8	17	3	25	25	....	....	3	1	3	127,260	129,304	88,213
Lower Susquehanna	20	17	1	37	37	....	4	1	4	4	159,304	157,403	137,556
Total of Pennsylvania	87	65	8	152	149	3	10	10	16	10	968,453	913,085	775,[illegible]
Maryland	3	2	....	5	4	1	....	....	....	....	21,908	20,407	22,344
Virginia	1	....	....	1	1	....	....	....	....	....	....	4,000	6,000
Total	130	87	11	217	207	10	13	13	21	14	1,369,812	1,312,754	1,292,14[illegible]

CHARCOAL AND BITUMINOUS COAL.

States.	No. of stacks in blast Dec. 31, 1874.	No. of stacks out of blast Dec. 31, 1874.	No. of stacks blown out in Jan., 1875.	Whole No. completed stacks Dec. 31, 1874.	Whole No. completed stacks Dec. 31, 1873.	No. of new stacks completed in 1874.	No. of new stacks completed in 1873.	No. of new stacks completed in 1872.	No. of stacks building in 1875.	No. of stacks projected in 1875.	Make of pig-iron in 1872, net tons.	Make of pig-iron in 1873, net tons.	Make of pig-iron in 1874, net tons.
Virginia	1	2	....	3	2	1	1	....	....	....	....	2,400	1,340
Alabama	....	2	....	2	2	....	....	....	....	....	....	....	2,400
Total	1	4	....	5	4	1	1	....	....	....	....	2,400	3,740

BITUMINOUS COAL AND COKE.

Pennsylvania:													
Shenango Valley	16	16	....	32	31	1	2	5	....	1	160,188	160,831	156,419
Allegheny County	5	6	1	11	11	....	....	4	1	2	110,599	158,789	143,660
Miscellaneous	13	19	....	32	32	....	1	....	2	4	117,224	111,014	97,968
Total of Pennsylvania	34	41	1	75	74	1	3	9	3	7	388,011	430,634	397,147
Maryland	....	4	....	4	4	....	....	....	....	2	12,079	5,264	7,209
Virginia	....	....	....	....	....	....	....	....	1	....	....	....	....
North Carolina	....	....	....	....	....	....	....	....	1	....	....	....	....
Georgia	1	....	....	1	1	....	1	....	....	....	....	....	5,516
West Virginia	3	2	....	†5	2	2	....	1	1	....	19,846	21,106	26,734
Kentucky	3	1	1	4	3	1	....	....	....	....	27,697	27,670	24,583
Tennessee	2	2	....	4	3	1	1	1	1	3	8,360	8,602	11,543
Ohio:													
Hanging Rock	3	7	....	10	7	3	1	1	5	3	23,169	28,601	26,015
Mahoning Valley	17	11	8	28	28	....	1	2	....	....	200,785	157,888	154,287
Miscellaneous	11	7	1	18	16	2	3	3	1	5	80,167	119,042	151,864
Total of Ohio	31	25	9	56	51	5	5	6	6	8	304,121	305,531	332,166
Indiana	3	4	....	7	7	....	....	2	....	1	39,221	32,486	11,632
Illinois	3	7	....	10	10	....	2	....	2	1	78,627	55,796	37,946
Michigan	1	2	....	3	3	....	....	....	....	....	13,382	795	3,672
Missouri	....	8	....	8	‡9	....	2	1	1	2	55,569	46,016	26,724
Total	81	96	11	177	167	10	14	20	16	24	946,913	933,900	884,872

† One stack altered from charcoal.

‡ One stack torn down.

CHARCOAL.

States.	No. of stacks in blast Dec. 31, 1874.	No. of stacks out of blast Dec. 31, 1874.	No. of stacks blown out in Jan., 1875.	Whole No. completed stacks Dec. 31, 1874.	Whole No. completed stacks Dec. 31, 1873.	No. of new stacks completed in 1874.	No. of new stacks completed in 1873.	No. of new stacks completed in 1872.	No. of stacks building in 1875.	No. of stacks projected in 1875.	Make of pig-iron in 1872, net tons.	Make of pig-iron in 1873, net tons.	Make of pig-iron in 1874, net tons.
Maine	1	....	....	1	1	....	....	....	....	....	....	780	1,661
Vermont	2	....	....	2	2	....	....	....	....	....	2,000	3,100	3,450
Massachusetts	4	1	1	5	5	....	....	....	....	....	12,820	15,704	17,777
Connecticut	3	7	....	10	10	....	....	....	....	....	22,700	26,977	14,518
New York	9	8	4	17	17	....	2	1	....	....	19,812	29,329	28,293
Pennsylvania	21	18	6	39	39	....	1	....	....	....	45,033	45,854	40,978
Maryland	10	4	2	14	14	....	....	....	....	....	29,044	30,315	25,003
Virginia	13	21	4	34	32	2	2	2	1	2	21,445	20,075	22,111
North Carolina	2	6	....	8	8	....	1	....	1	2	1,073	1,432	1,340
South Carolina	...	8	....	8	8	....	....	....	....	....	....	....	....
Georgia	3	6	....	9	7	2	1	....	3	2	2,945	7,501	4,270
Alabama	6	6	1	12	9	3	3	....	2	3	12,512	22,283	30,463
Texas	....	1	....	1	1	....	....	....	....	1	619	280	1,012
West Virginia	2	2	....	4	4	1	1	....	1	....	950	1,950	3,400
Kentucky	8	15	6	23	22	1	....	....	....	2	39,699	42,219	36,644
Tennessee	11	7	6	18	17	1	....	....	....	3	34,094	34,532	37,227
Ohio:													
Hanging Rock	28	6	8	34	33	1	....	....	....	....	87,440	92,365	85,873
Miscellaneous	....	3	....	3	§4	....	....	....	....	....	8,182	8,133	6,962
Total of Ohio	28	9	8	37	37	1	....	....	....	....	95,622	100,498	92,835
Indiana	....	1	....	1	1	....	....	....	....	....	....	....	2,100
Michigan	15	14	2	29	28	1	6	2	....	6	86,616	113,475	128,969
Wisconsin	4	7	....	11	10	1	2	1	....	....	27,790	38,880	28,973
Minnesota	....	1	....	1	....	1	....	....	....	....	....	....	....
Missouri	8	3	....	11	9	2	2	....	....	3	45,589	39,536	49,093
Oregon	1	....	....	1	1	....	....	....	....	1	....	....	2,500
Utah	1	....	....	1	....	1	....	....	1	....	....	....	200
Total	152	145	40	297	282	17	21	6	9	25	500,363	574,720	572,817

§ One stack abandoned in 1874.

ANTHRACITE COAL AND COKE.

States.	No. of stacks in blast Dec. 31, 1874.	No. of stacks out of blast Dec. 31, 1874.	No. of stacks blown out in Jan., 1875.	Whole No. completed stacks Dec. 31, 1874.	Whole No. completed stacks Dec. 31, 1873.	No. of new stacks completed in 1874.	No. of new stacks completed in 1873.	No. of new stacks completed in 1872.	No. of stacks building in 1875.	No. of stacks projected in 1875.	Make of pig-iron in 1872, net tons.	Make of pig-iron in 1873, net tons.	Make of pig-iron in 1874, net tons.
Wisconsin	1	2	....	3	3	....	1	....	....	....	37,246	35,268	21,519
Michigan	....	1	....	4	1	....	....	1	....	....	....	8,736	4,021
Total	1	3	....	4	4	....	1	1	....	....	37,246	44,004	25,540

RECAPITULATION.

	No. of stacks in blast Dec. 31, 1874.	No. of stacks out of blast Dec. 31, 1874.	No. of stacks blown out in Jan., 1875.	Whole No. completed stacks Dec. 31, 1874.	Whole No. completed stacks Dec. 31, 1873.	No. of new stacks completed in 1874.	No. of new stacks completed in 1873.	No. of new stacks completed in 1872.	No. of stacks building in 1875.	No. of stacks projected in 1875.	Make of pig-iron in 1872, net tons.	Make of pig-iron in 1873, net tons.	Make of pig-iron in 1874, net tons.
Charcoal	152	145	40	297	282	17	21	6	9	25	500,363	574,720	572,817
Bituminous coal and coke	81	96	11	177	167	10	14	20	16	24	946,913	933,900	884,872
Anthracite	130	87	11	217	207	10	13	13	21	14	1,369,812	1,312,754	1,202,144
Anthracite coal and coke	1	3	....	4	4	....	1	1	....	....	37,246	44,004	25,540
Peat and charcoal	....	1	....	1	1	....	....	1	....	....	224	500	....
Charcoal and bituminous coal	1	4	....	5	4	1	1	...	....	....	....	2,400	3,740
Total	365	336	62	‖701	665	38	50	41	46	63	2,854,558	2,868,278	2,689,413

‖ Two furnaces, not included here, were abandoned in 1874.

Stock of pig-iron unsold December 31, 1874.

States and districts.	Anthracite, net tons.	Bituminous coal and coke, net tons.	Bituminous coal and charcoal, net tons.	Charcoal, (low grade,) net tons.	Charcoal, (car-wheel,) net tons.	Total, net tons.
New England[¶] and New York	101, 096			10, 680	26, 448	138, 224
New Jersey	37, 959					37, 959
Pennsylvania:						
Charcoal				11, 225	10, 308	21, 533
Lehigh Valley	28, 791					28, 791
Schuylkill	40, 787					40, 787
Upper Susquehanna	12, 868					12, 868
Lower Susquehanna	22, 990					22, 990
Shenango		87, 650				87, 650
Allegheny County		12 230				12, 230
Miscellaneous		15, 591				15, 591
Total for Pennsylvania	105, 436	115, 471		11, 225	10, 308	242, 440
Maryland	4, 497	3, 853		1, 221	6, 387	15, 958
Southern States		1, 008	2, 981	17, 235	17, 818	39, 042
West Virginia		5, 601		870	2, 500	8, 971
Kentucky		8, 080		20, 657	4, 255	32, 992
Tennessee		2, 781		23, 765	1, 220	27, 766
Ohio:						
Hanging Rock		11, 450		50, 717	7, 580	69, 747
Mahoning Valley		25, 777				25, 777
Miscellaneous		11, 952		10, 608		22, 560
Total for Ohio		49, 179		61, 325	7, 580	118, 084
Michigan and Indiana[**]		8, 796		53, 558	4, 333	66, 687
Illinois		7, 229				7, 229
Wisconsin				8, 699	439	9, 138
Missouri		11, 500		38, 764	1, 030	51, 294
Grand total	248, 988	213, 498	2, 981	247, 999	82, 318	795, 784

[¶] New England has but one anthracite furnace.

[**] Indiana has but one charcoal furnace.

Imports of iron and steel and manufactures thereof into the United States from all countries during the fiscal years 1871 *to* 1875.—*Gold values.*

Commodities.	1871.		1872.		1873.		1874.		1875.	
	Net tons.	Values.	Net tons.	Values.	Net tons.	Values.	Net tons.	Values.	Net tons.	Values.
Pig-iron	199,515	$3,106,490	277,232	$5,122,318	241,355	$7,203,769	103,086	$3,288,022	60,198	$1,457,941
Castings	2,203	32,679	433	34,333	364	32,113	215	15,905	87	3,368
Bar-iron	101,751	4,058,126	118,227	5,153,472	83,008	5,288,481	38,515	3,022,311	26,552	1,728,137
Boiler-iron	549	31,284	700	57,392	587	55,030	77	11,177	64	9,229
Band, hoop, and scroll iron	11,220	506,501	11,708	573,457	12,830	846,973	3,007	200,574	429	24,062
Railroad bars or rails of iron	513,022	17,360,297	472,365	15,778,941	240,504	10,541,036	20,379	987,260	2,198	69,284
Railroad bars or rails of steel*	....	....	122,955	6,277,694	160,041	9,199,666	146,410	9,771,175	44,934	2,863,027
Sheet-iron	10,488	610,809	14,754	1,116,200	14,943	1,287,072	6,166	808,016	5,358	852,426
Old and scrap iron	174,502	3,782,526	258,455	6,040,678	228,567	6,643,512	57,530	1,495,142	36,298	792,772
Hardware	....	141,495	....	204,992	....	371,518	....	265,678	....	311,807
Anchors, cables, and chains of all kinds	5,525	472,782	5,505	490,275	5,799	675,184	3,498	437,582	2,892	339,806
Machinery	....	907,371	....	1,054,045	....	1,693,966	....	1,293,774	....	697,100
Muskets, pistols, rifles, and sporting-guns	....	706,988	....	711,858	....	822,119	....	873,430	....	655,204
Steel ingots, bars, sheets, and wire	....	3,750,702	....	4,033,508	....	4,155,234	....	2,960,055	....	2,539,906
Cutlery	....	1,956,351	....	2,143,708	....	2,234,355	....	1,586,194	....	1,440,418
Files	....	604,153	....	583,058	....	770,986	....	575,211	....	359,435
Saws and tools	....	514,346	....	542,377	....	265,637	....	48,210	....	24,712
Other manufactures of iron and steel not elsewhere specified	....	4,883,075	....	5,621,882	....	7,221,801	....	6,153,830	....	4,307,616
Total	1,018,775	43,425,975	1,282,334	55,540,188	987,998	59,308,452	378,883	33,793,546	179,010	18,476,230

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* Previous to July 1, 1871, reported under head of iron rails.

Commodities.	Net tons.	Values.	Net tons.	Values.	Net tons.	Values.	Net tons.	Values.
Pig-iron	245, 535	$3, 797, 298	295, 967	$7, 269, 850	154, 708	$5, 181, 847	61, 165	$1, 738, 438
Castings	441	28, 260	407	38, 564	262	19, 169	74	6, 285
Bar-iron	122, 565	5, 024, 686	89, 576	4, 837, 532	62, 253	4, 481, 614	26, 876	1, 946, 793
Boiler-iron	322	27, 351	684	59, 993	464	44, 324	53	7, 669
Band, hoop, and scroll iron	13, 098	594, 166	12, 379	748, 509	8, 245	537, 140	1, 425	91, 475
Railroad bars or rails, of iron	566, 202	19, 132, 359	381, 064	14, 498, 012	99, 201	4, 708, 189	7, 796	393, 589
Railroad bars or rails, of steel*	....	....	149, 786	8, 207, 013	159, 571	8, 984, 103	100, 486	6, 838, 875
Sheet-iron	12, 047	857, 895	10, 149	1, 263, 112	10, 713	1, 090, 486	6, 736	1, 007, 988
Old and scrap iron	220, 340	4, 845, 092	278, 257	7, 617, 463	108, 838	3, 061, 759	40, 746	949, 942
Anchors, cables, and chains of all kinds	5, 434	460, 116	5, 875	622, 908	4, 668	565, 656	3, 219	390, 619
Hardware	....	134, 427	....	325, 208	....	238, 706	....	303, 728
Machinery[†]	....	891, 408	....	1, 148, 713	....	1, 941, 053	....	802, 570
Muskets, rifles, pistols, and sporting-guns	....	599, 388	....	811, 872	....	886, 307	....	691, 990
Steel ingots, bars, sheets, and wire	....	3, 460, 735	....	4, 106, 087	....	3, 865, 316	....	2, 678, 611
Cutlery	....	2, 051, 750	....	2, 272, 467	....	1, 989, 595	....	1, 453, 570
Files	....	595, 539	....	676, 814	....	744, 798	....	430, 688
Saws and tools	....	695, 275	....	476, 927	....	52, 509	....	32, 674
Other manufactures not specified	....	4, 724, 181	....	6, 743, 183	....	7, 322, 099	....	4, 835, 216
Total	1, 185, 984	47, 919, 926	1, 224, 144	61, 724, 227	608, 923	45, 764, 670	248, 576	24, 600, 720

* Previous to July 1, 1871, reported under the head of iron rails.

Domestic exports of iron and steel and manufactures thereof from the United States to all countries during the calendar years 1871, 1872, 1873, *and* 1874.—*Currency values.*

Commodities.	1871.		1872.		1873.		1874.	
	Quantities.	Values.	Quantities.	Values.	Quantities.	Values.	Quantities.	Values.
IRON, AND MANUFACTURES OF:								
Pig-iron .... Net tons	2, 330	$67, 481	1, 477	$72, 818	10, 103	$414, 349	16, 039	$447, 619
Bar-iron .... do	179	14, 830	329	31, 929	367	40, 404	4, 717	331, 341
Boiler-plate iron .... do	24	3, 517	33	5, 041	125	14, 519	122	13, 219
Railroad bars or rails .... do	333	23, 813	1, 212	86, 820	375	30, 743	1, 257	73, 159
Sheet, band, and hoop .... do	30	3, 518	165	13, 781	49	7, 108	86	12, 284
Castings, not specified .... do		126, 499		144, 653		201, 459		271, 276
Car-wheels .... Number	4, 043	82, 467	4, 873	97, 090	12, 274	196, 438	6, 644	137, 589
Stoves, and parts of		79, 909		101, 959		101, 397		141, 953
Steam-engines, locomotives .... Number	62	820, 943	55	774, 296	68	1, 109, 482	77	1, 145, 669
Steam-engines, stationary .... do	42	105, 857	40	89, 556	49	125, 037	41	51, 296
Boilers, separate from engines		114, 705		166, 554		254, 240		95, 604
Machinery, not specified		1, 890, 880		3, 160, 538		3, 011, 111		4, 153, 258
Nails and spikes .... Net tons	2, 355	245, 289	2, 682	322, 879	3, 409	371, 663	5, 139	481, 010
All other manufactures of iron not specified		2, 191, 059		2, 737, 588		3, 528, 941		3, 279, 704
Total		5, 770, 767		7, 805, 502		9, 406, 941		10, 636, 981
STEEL, AND MANUFACTURES OF:								
Ingots, bars, sheets, and wire .... Net tons	30	7, 364	9	3, 624	26	5, 481	343	29, 557
Cutlery		90, 064		31, 889		54, 409		50, 805
Edge-tools		532, 395		691, 415		862, 096		875, 538
Files and saws		13, 222		14, 536		16, 520		28, 173
Muskets, pistols, rifles, and sporting guns		5, 215, 128		1, 165, 424		1, 548, 227		3, 613, 430
All other manufactures of steel, not specified		207, 197		317, 735		236, 265		157, 323
Total		6, 065, 370		2, 224, 623		2, 722, 998		4, 754, 826
AGRICULTURAL IMPLEMENTS:								
Fanning-mills .... Number	36	1, 066	25	689	120	4, 330	48	1, 379
Horse-powers .... do	25	10, 410	26	7, 876	43	5, 726	95	47, 806
Mowers and reapers .... do	3, 509	377, 719	6, 636	765, 511	9, 882	1, 266, 761	17, 230	1, 886, 324
Plows and cultivators .... do	12, 999	169, 764	24, 781	320, 493	27, 008	368, 462	13, 109	169, 032
All other not specified		461, 861		670, 509		868, 703		1, 041, 952
Total		1, 020, 820		1, 765, 078		2, 513, 982		3, 146, 493
Scales and balances		107, 516		173, 423		187, 380		134, 996
Sewing-machines		2, 232, 697		2, 376, 873		1, 829, 675		1, 770, 951
Fire-engines and apparatus		9, 009		15, 118		96, 778		16, 485
Grand total		15, 296, 179		14, 300, 617		16, 687, 754		20, 400, 739

CHAPTER IX.

JAPAN, CHINA, TURKESTAN, INDIA, NEW ZEALAND, AND AUSTRALIA.

THE IRON-ORES AND THE STEEL OF JAPAN; JAPANESE FURNACE; CHINESE EXHIBIT OF IRON-ORES AND IRON FROM THE MARINE ARSENAL AT FOUCHOW; NATIVE CASTINGS FROM TURKESTAN; IRON AND STEEL OF BRITISH INDIA; INDIAN COALS; NATIVE FURNACE AND METHODS OF PRODUCING IRON; WOOTZ OR INDIAN STEEL; BUTTONS AND FORGED INGOTS OF; DEPOSITS OF IRON-ORE; NEW ZEALAND; ILFRACOMBE IRON COMPANY'S STEEL BELL.

167. THE IRON-ORES AND THE STEEL OF JAPAN.—The Japanese, who have entered most intelligently into the true spirit of the exhibition, have brought with them the best collection of their minerals yet seen abroad. In this collection we find their iron-ores chiefly in the form of iron-sand from the beaches of the volcanic shores of Nipon and Yesso. Magnetic and limonite ores are not wanting, but the disintegrated sandy ore is most used, being better suited than the massive ores to their primitive methods of manufacture. Their fuel is charcoal, and it is piled, together with the ore, in small quadrangular furnaces about 20 feet high. The blast is thrown in at the side from double bellows, worked by hand, and when sufficient ore has been reduced to form a bloom an opening is made in the front of the furnace, and the mass is pulled out and forged by hand. After several reheatings and forgings, rough disks of iron are obtained, which are cut up by chisels into short strips or bars ready for sale. A series of such bars, ranging from one to two feet in length, are in the collection.

There is also a model of the furnace commonly used. It has a square base and a pyramidal shaft, with an opening in front and two tuyere-holes on opposite sides. The model is one-twentieth of the size of the furnace, and from this the dimensions which follow are taken: Base, 10 feet square; height, 5 feet 10 inches; stack, 25 feet high. It appears to be like the old German oven or "stuhl" furnace, in which blooms only were made and pig-iron was an accidental product. The bottom or hearth is filled with charcoal and ashes, then the stack is similarly lined. A square opening is left in the back for charging the ore and fuel.

About the year 1860 an attempt was made to work the sand-ore of Yesso in a high blast-furnace, built after a European model, by Takeda, a talented Japanese engineer, but it was abandoned after an inspection and report to the government by the writer and Mr. Pumpelly. Since then, near Yamukshinai, on Volcano Bay, small furnaces have been erected for making blooms. The furnace is torn down in front upon the completion of the process for each charge. The bloom generally weighs about one-third as much as the charge.*

Magnetic iron-ore of good quality exists in Nambu, at the northern end of Nipon, and has been successfully worked by Mr. Ohosima.

In addition to the bar-iron a great many samples of steel were shown. The steel is peculiar, and the precise method of its manufacture is not known. It is in irregular, spongy, or cellular masses, looking like slag or some meteorites. Although sufficiently brittle to be broken up into fragments, as desired by purchasers, it is malleable, and may be wrought into bars. The quality is excellent. Some of these specimens of steel were from the north part of Choisiu, or near it, and are called "mother of bar-steel;" others are from Hakoni, near Fusi-no-yama and from Oisiu.

168. CHINA.—The short and roughly-forged blooms and bars of iron sent from the interior of China show that methods of production similar to those of Japan prevail there. The work of developing the vast deposits, both of ore and of coal, which that country is known to possess has not yet commenced on a large scale under the direction of foreigners, but there is a large government establishment at the Fouchow marine arsenal, province of Foukien, which was represented in an interesting manner in the Chinese section. At this establishment the native iron product of Foukien and the surrounding country is worked up into merchantable bars and rods. The works are superintended by foreigners employed by the government, under a commission from Pekin, Prosper Gujal director, assisted by a committee of four mandarins of high rank. Some 2,500 Chinese are employed, and there are 130 officers and superintendents. The list includes 600 carpenters and marines, 800 workmen and apprentices, 500 laborers, 500 soldiers, 130 officers and superintendents.

This establishment sends a very interesting series of its products, consisting chiefly of forged bars and rods bent and broken in various ways to exhibit the quality, and all of which show a high degree of excellence. The greater part of the native iron is delivered to the works in the shape of small blooms weighing only four or five pounds. The ore, a fine black sand, like old-fashioned desk-sand, is a mixture of ordinary quartz river-sand with magnetic iron-sand, and is obtained by washing the river-sand, which sometimes does not yield over 1½ to 2 per cent. of ore. Five hundred pounds of ore yield, in their rude furnaces, about one hundred and fifty pounds of impure iron, which, by reheating and forging, is finally reduced to only eighty-three pounds. When these rough blooms and bars are combined and forged into commercial bars there is a further loss, but a very tough and fibrous iron is obtained. A very considerable quantity of old iron from condemned vessels, wrecks, and other sources is obtained at the sea-ports, and this is also worked up at the arsenal. This establishment has been in successful operation since October, 1867, and appears to be giving not only important commercial results but to be educating a great number of the Chinese in western industrial methods.

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* Blakiston, Journey in Yesso, Jour. Geog. Soc., 1872, 136.

169. CENTRAL ASIA—TURKESTAN.—There are interesting specimens of native castings from Turkestan, made, in part at least, according to the catalogue published by the imperial Russian commission, by melting up the broken and disused imported iron castings. The furnaces are very rude. They line the interior of a cast-iron pot with a layer of clay 1½ inches thick and fill it with charcoal, lighted at the bottom. A blast is thrown in from a tuyere just above the edge of the vessel and is directed downward toward the bottom. The charge of cast iron is piled upon the charcoal in pieces weighing from twenty to sixty pounds. Charcoal and more iron are added, as needed, until the pot is filled with molten iron. The slags and scoriæ being skimmed off, the iron is dipped out and the castings are made in moist sand. The blast is obtained from two leather sacks fitted with valves and worked by hand, so as to give a nearly continuous blast.

BRITISH INDIA.

170. The iron and steel products of British India are shown in the Indian collection, where we find a great variety of iron-ores and coals, one variety of the latter giving a very superior coke well adapted to the production of iron. Large blocks of magnetic, specular, and hematite ores bear witness to the wealth of India in the raw material, while the diminutive bars and hand-made blooms show that the industry of iron has not made progress generally beyond the primitive methods.

Through the labors of Dr. Oldham and his assistants of the geological survey of India, the great resources of that country in ores of iron have been made known. Superior magnetic ore exists in mountain masses near Salem and other places. Three separate attempts have been made to establish the manufacture of iron in India on a large scale, and considerable British capital, aided by the government, has been invested there, but up to this time without adequate success. Nothing has been done in this direction for several years, but renewed attention is being given to the subject, and Mr. Bauerman, a mining engineer, has been sent out from England to examine and report upon the mines, with a view to the erection of iron works on a large scale. One of the great difficulties want of proper fuel—has been removed by the discovery of a bed of good coking coal. The India coals belong not to the Carboniferous but to the Triassic series, and are allied, in their nature and age, to those of China.

The native production of iron is confined to the poorer classes. They make plow-points, spades, &c., but for wagon-tires they prefer foreign bars. The method of working was clearly shown by a very interesting model of a native iron furnace and its surroundings, showing the whole operation of smelting, forging, and reheating. The ore is broken up by hand into small grains, and is charged into a low, box-like furnace, about four feet high and three feet and a half broad, with a large opening at the base in front. On each end there is a box four feet by two to hold ore and fuel.

The blast is supplied by bellows made of sheep or goat skin, worked by two women, and the bloom, when pulled out of the furnace, is chopped up by men with heavy hatchet-shaped hammers. The pieces are reheated and forged out. About twelve hours are required to each charge and the product is about one-third in weight of the ore charged. The ore is added at the top in layers with charcoal.

The reheating furnace is also very simple and primitive in its construction, being a box or oven about 6 feet long and 4 feet high, built over the blooms upon the ground. The blast is thrown in at the side.

According to Dr. Oldham, in the memoirs,[*] also on exhibition, the native furnaces range in height 3 to 5 feet, with an interior diameter of from 9 inches to 1 foot. They stand about 2 feet wide upon the ground, and taper upward, the back part more than the front. They are made of red clay, mixed with sand. The linings of clay last only three or four days. An excavation about a foot in depth is made for a hearth for the bloom. The opening in front is from 12 to 14 inches high, and is closed up during the operation. The blast is obtained by hand-power from skin-bellows, and the tuyeres are made of bamboo or sheet-iron covered with clay. A strong heat, varying in duration from two and one-half to four hours, is sufficient to give a bloom. An opening is then made in front, the bloom is drawn out, and while hot is cut into two parts by ax-like sledges. The usual charge is about eighteen pounds of ore, and the average product, with four men at each furnace, is three blooms in twelve hours. Such blooms are reheated several times, and hammered and worked into rude bars about one foot long and two inches wide. Wootz or Indian steel is prepared from such bars.[†] In 1860, a tax amounting to Rs. 1210–12–7 was raised on 775 such furnaces, while in 1859, 928 furnaces yielded Rs. 1451–1–7.

171. WOOTZ OR INDIAN STEEL.—Of equal, if not greater, interest, is a series of specimens of the famous "wootz" or Indian steel. It is crucible steel, made in small quantities, and from carefully-selected materials.

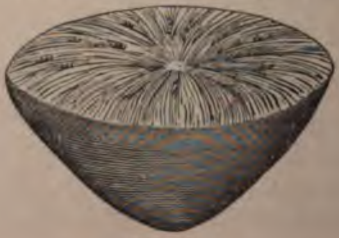

Fig. 65.

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[*] Memoirs Geological Survey of India, iv, 155.

[†] See an account by Mr. Heath, Jour. Roy. Asiatic Soc., v.

The small clay crucibles, or pots, not over 4 inches high, are shown, together with the "button" as it remains in the crucible after cooling. The contents, after the fusion, are not poured out into a mold, but remain undisturbed in the bottom of the vessel. These buttons weigh only a few ounces, and are interesting from the peculiar crystallization which forms in the mass, and shows distinctly by fine raised radial lines on the surface.

BUTTON OF WOOTZ.—These buttons are malleable, and some are shown forged out into small square bars ready for market. Care is taken to leave traces of the crystalline markings at one end of the bar. They have every appearance of homogeneity, but a sample submitted to tests gives evidence of a different condition. The bar presented to me by the commissioners (No. 131 of Indian catalogue) has, at my request, been forged or drawn out at the Griswold Bessemer Steel Works, in Troy, and under the supervision of Mr. A. L. Holley, who reports it drew well at a low Bessemer heat, and when annealed broke off short, when cold, and would not bend at all on three trials. Fracture fine. "The ingot is apparently full of cinder, and is hence shaky and seamy." A piece drawn to a cold chisel, and tempered as usual, did not stand well. The experiments were carefully made, and the steel was not overheated. Evidently the ordinary treatment does not answer for this steel. The radial crystallization of the button is evidence of a difference of composition within the mass, one portion being apparently more fusible than the other. When drawn out this gives the effect of included "cinder."

172. IRON-ORES OF INDIA.—There are vast deposits of iron-ore in Northern India, near Kumarm and on Nerbudda River, and they are generally distributed over Northern India, but usually far from suitable fuel, even from forests. These ores are the magnetic and hematite, (specular.) Of the Salem iron region, "Kunjamullay" Oldham (iv, 157,) says they are close to railway lines, in gneissic rocks, forming a mountain. There are three principal beds of magnetic iron-ore, besides two others that crop to a limited extent. The two lower beds form conspicuous outcrops, and average say 50 feet in thickness, each. There are vast quantities of *débris* all about the mountain extending for one or two miles. The yield of the Porto Novo Company's furnace, at Beypoor, was about 55 per cent. of pig-iron, requiring 13¼ tons of coal for each ton of pig-iron obtained.

INDIA COAL.—There is only one good coking coal known in India at present. It is from Sanktoria colliery, Raniguuj coal-field, Lower Bengal, and gives from 74 to 76 per cent. of good coke, a large specimen of which, nearly two feet long, is shown with the other minerals of India. This field is considered to be the chief coal-field of India, and is probably Lower Oolite or Triassic in age. There are many different beds, and it is singular that some of them do not give a coking coal. The production (1873) is now nearly 484,642 tons annually, and it is increasing. The mines are all worked with uncovered lamps. No Carboniferous coal is known in India, but it is supposed that there may be some in Burmah.

New Zealand.—The New Zealand court of the Exhibition contained a variety of specimens of magnetic, specular, and limonite ores, sent by the Colonial Museum. Among these the following may be noted: Magnetic iron-ore from Dun Mountain, Nelson, forming a vein 16 inches thick in serpentinous strata, also from Otago in mica schists. Specular ore (hematite) from the same localities, in regular veins in greenstone, (at Dun Mountain,) and in a 6-foot vein at Shotover, Otago. The black-iron sand from the beach at Taranaki was also represented, together with blooms and ingots, and bars of titanic steel and of workable steel. The ingot is a spongy, porous mass internally, but is compact at the surface and edges. The bar of crude titanic steel is 16 by 1½ by ½ inches.

The Ilfracombe Iron Company exhibited a bell of fine tone, cast from the steel made by the company.

CHAPTER X.

HYDRAULIC FORGING.

RTS OF LOCOMOTIVES SHOWN BY HASWELL, AT VIENNA; ETCHED SURFACES, ITING THE "FLOW" OR STRUCTURE; THE PROCESS AT THE STATE RAILWAY KS; FORGING INGOTS, CAR-WHEELS, AND BOILER-HEADS; TRANSLATION OF ELL'S MEMOIR; THE PRESS; WROUGHT-IRON CROSS-HEADS; JOURNAL-BOXES; MOTION SLIDING-BLOCKS; CYLINDER-HEADS; LOCOMOTIVE WHEELS AND CRANKS; TRATIONS OF THE MANUFACTURE OF CAR-WHEELS UNDER THE PRESS.

The Austrian section contains examples of successful forging of ite objects of large size in iron and steel, by Mr. Haswell, engineer Imperial State Railway Works, at Vienna. The objects shown iefly axle-box frames, cross-heads for locomotive pistons, link-bars, nd have been sliced longitudinally and then etched with acid so develop the grain or fiber and show its flow in the mold and gen- onformity to the shape of the object.

. This method of forging, known as "Haswell's system," has been d by him to a great degree of perfection, and is used in Vienna great economy, while it gives results superior to those obtained by rdinary methods. It consists essentially in forcing or pressing r steel, while at a welding heat, into suitable molds by means of ydraulic press, carrying a follower or "stamp" upon the end of the i. Both the mold and the stamp are used cold. Ingots or bars be similarly forged or drawn down without a mold upon an anvil, ut giving any blow or shock, as there is of necessity when heavy -hammers are used.

the courtesy of Mr. Haswell I was admitted to the works, and a the operation of the two powerful hydraulic presses upon both s and parts of locomotives.

small press with an 18-inch piston gives 600 tons pressure, and rge press with a piston 24 inches in diameter gives 1,200 tons ure. The pressure in the pumps is 600 atmospheres.

oft Bessemer-steel ingot, weighing 2,030 pounds, was forged under rge press, and yielded noiselessly to the pressure as if it had been or soft cheese. As the piston-head descends, the metal is forced way, and the pressure visibly extends to the very center of the , as shown by the movements of the lines of scale at the sides. nds of the ingot are bulged out at the center, and not drawn over e surface, as is often the case with hammer-forging, which, com- d with hydraulic-press forging, seems very superficial. Under the form of the cross-head is impressed into the upper part, and in the lower part, *b*, the form of the rest of the cross-head is made by the conical side pieces *c c*. These pieces are so made as to permit of their removal from the mold with the cross-head. The disk *f* determines the height of the shoulder for the piston-rod, and can be made thicker or thinner as desired. The disk *f*, also the side pieces *c c*, are put into the lower mold from above before the parts *a* and *b* are put together. G is the die which is fastened to the head of the press, and which closes up the mold at *h h* as far as the canals *p p*, (which must be kept open for the exit of the air,) where it meets the prolonged side of the cross-head. The die G consists of two parts, *g g*, of which the upper part is made of cast iron, but the lower part must be made of cast steel, on account of its rapid destruction by burning off. The two bed plates, *q q*, limit the stroke of the press, and consequently the thickness and height of the cross-head. The mold rests upon a bed-plate, *o o*, (upon the height of which depends the length of stroke of the press,) and this bed-plate is placed upon a slide to permit of its being moved to the right or to the left from under the press. After the mold has been placed in the right position beneath the die, the props are adjusted to keep it in its proper

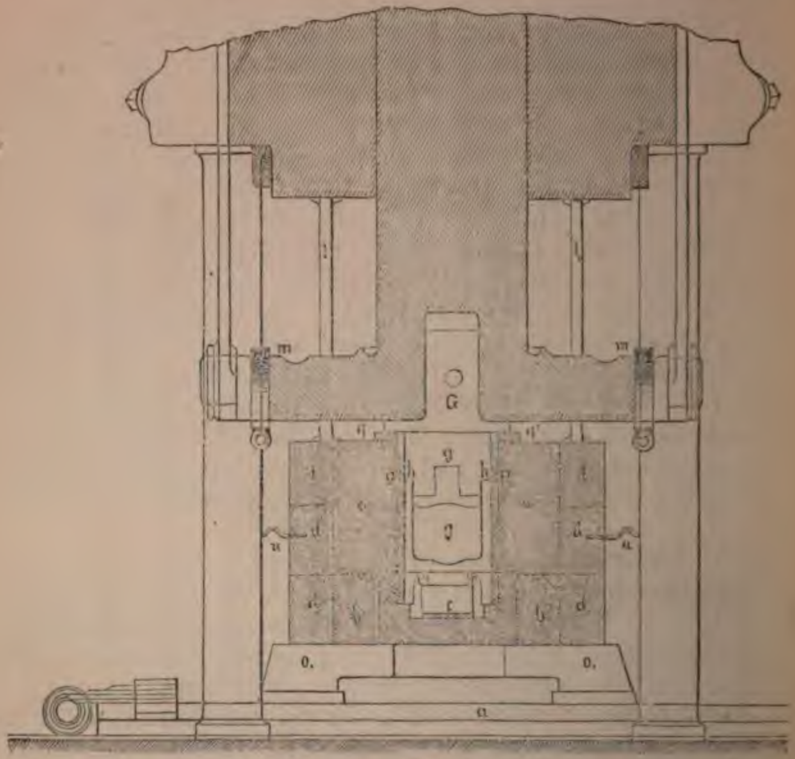

FIG. —Haswell's press, vertical section.

lace during the operation of pressing and the inside is greased to faciliate the removal of the pressed piece.

The iron to be pressed must be at a strong welding heat when placed n the mold, and one single pressure then produces the cross-head. To ake the finished cross-head from the mold, there are on the outside of he upper part two strong iron hooks, *u u*, by which it is fastened to the ead of the press at *m m* with chains after the removal of the props. The side pieces *c c*, as shown in Fig. 112, start from the lower mold hen the upper mold is drawn up, and are separated from the cross-ead by a gentle stroke of the hammer. The lower mold is then reoved from beneath the press by means of the fore-mentioned slide, (see 'ig. 111,) and the upper mold put upon the foundation frame *b b*, which omes to stand in place of the former mold. The chains are now reoved, the die G raised out of the mold as shown in figure 112; the ieces *g g*, which fit in the mold on the side of the die at **Z**, are placed position against the top of the cross-head, and then, by a gentle presure, the finished cross-head is forced out of the mold.

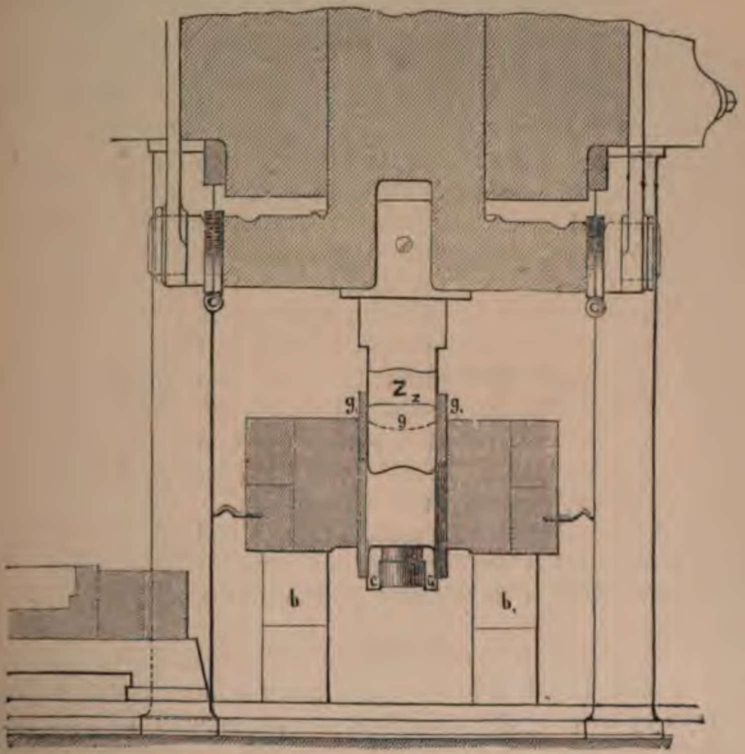

FIG. 112.—Haswell's press.

General remarks.—In the manufacture of cross-heads, bed-plates, joural-boxes, and all such parts as must be made in a closed space, the press, the whole mass of the ingot is affected. One great advantage of this method is the avoidance of great shocks, attendant upon the use of ponderous steam-hammers.

176. In forging intricate pieces, the molds are so made that they can be taken apart, and are held during the forging by strong bands. The follower, or stamp, is made of cast iron. The inside of the mold is oiled with old grease from railway-boxes. A lump of white-hot steel of the proper weight is thrown in; the stamp descends upon it and forces the metal into every recess and angle of the mold. Any excess of metal rises at the sides of the stamp, and is cut off when cold. Such forgings are alike in size and weight, and, of course, require much less trimming and fitting to bring them into shape for finishing. Care is required, of course, to get the right quantity of metal, to avoid a deficiency or an excess.

The method is successfully applied to the manufacture of car-wheels, the spokes and parts of the hub being forged in one piece, together with the crank-pin. Boiler-heads are made under the press in two heats. They are forced through a ring, and come out very true and perfect in form.

177. The importance of this method of manufacture to the industries of the United States justifies more than this brief notice, and as Mr. Haswell favored me with an illustrated copy of his descriptive *brochure* published in German in Vienna, I have had it translated and abridged for this report, and append it.*

MANUFACTURE OF PARTS OF LOCOMOTIVES BY PRESSURE.

By Robert Lane Haswell.

[Translation.]

Forging by the action of Haswell's patent hydraulic-press, which was for the first time attempted in the machine-shops of the Austrian States Railroad Company, in 1861, has since been so materially improved, that at the present time there are but few parts of a locomotive which cannot be made by this method.

It may be said that this process is essentially identical with the common process of swaging with the steam-hammer, but to the close observer it is evident that Haswell's system greatly excels, since the pieces made by it are much more perfectly shaped, and by it it is possible to press out such pieces or parts which could not be hammered out with the swage-hammer; and further, this process is much more economical; renders it possible to produce those parts of a locomotive which hitherto have been made of two or more pieces in one piece; and lastly, there is a great saving of time and therefore of money.

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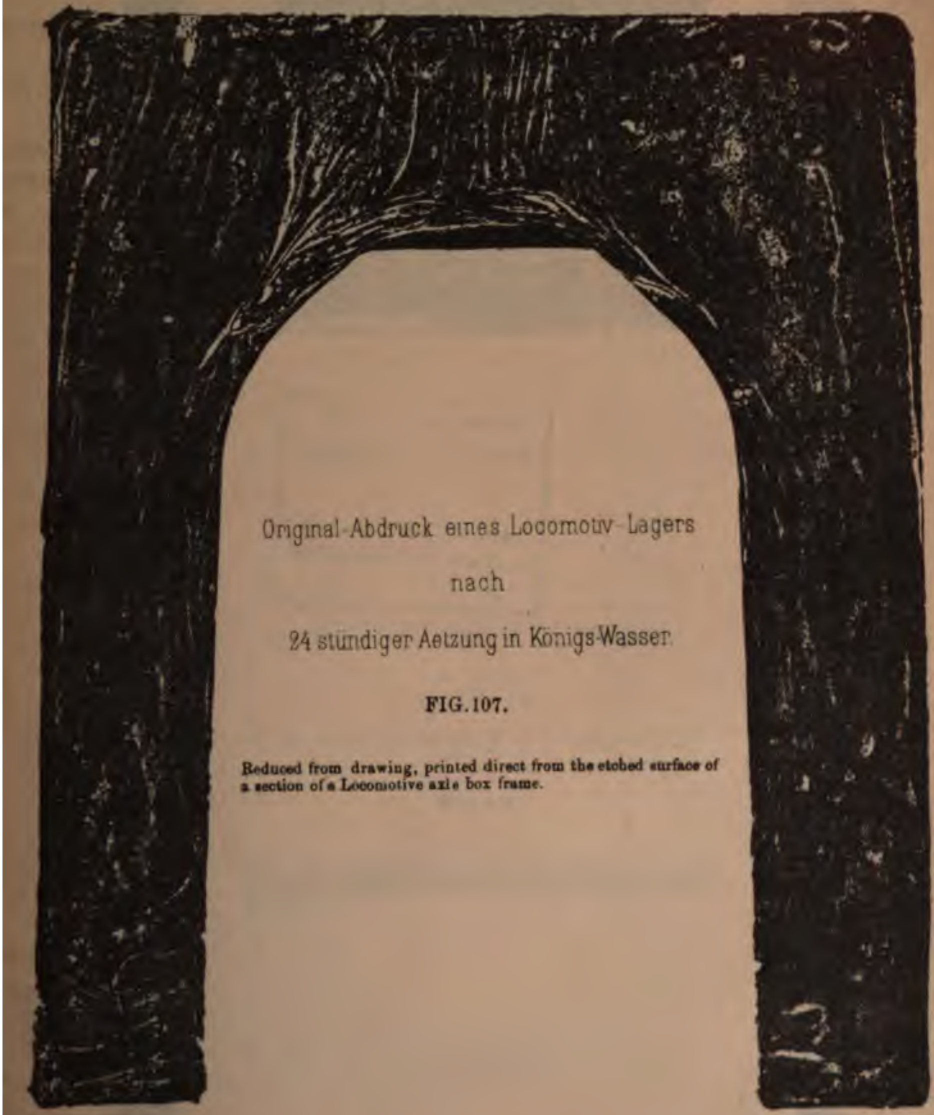
* Fabrication von Locomotiv-Bestandtheilen durch Pressen system Haswell. Von Robert Lane Haswell. Mit 5 Tafeln. Wien, 1873. (Separat-Abdruck aus der Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines, XII. u. XV. Heft. 1872.)



SCHNITT EINES GEPRESSTEN BALANCIER-FEDER BUGELS

in Konigs Wasser geätzt

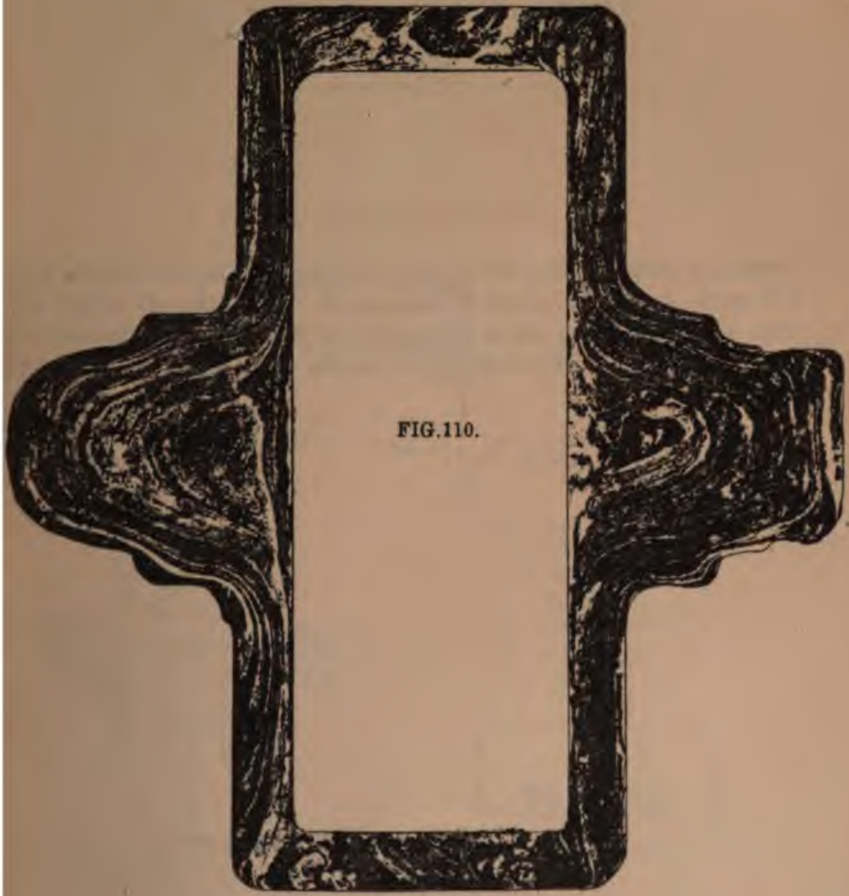


FIG.110.

[illegible] RY

[illegible] NS
L

Method of manufacture.—The bloom is composed of about 525 pounds of scrap-iron, which, as before, is hammered out, cut into four pieces, and heated in the heating-furnace.

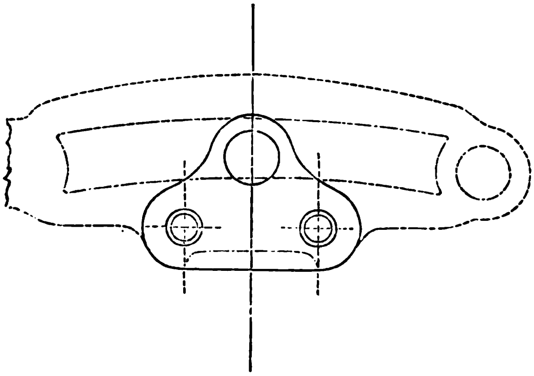


FIG. 113.—Sliding-block and link.

In Fig. 115 a view of the mold is given in its position after the pressing, but before the punching. It consists of the upper part A, (Figs. 115 and 116,) which rests upon the lower part B at the point *d;* of the side-pieces *u u* and *f*, which give shape to the *sliding-block;* and, lastly, of the die C, (Fig. 115.) The side-pieces *f* and *u u* are placed in the lower mold before the upper one is placed upon it. The side-piece *f* is held in position by the prop or wedge *n*, (Fig. 115.) This piece serves in the shaping of the piece, but is removed when the piece is punched.

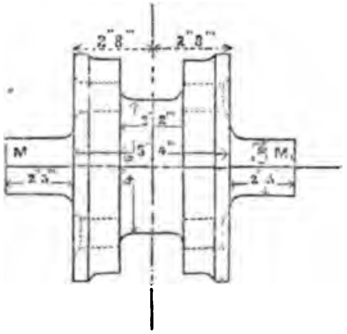


FIG. 114.—Front of sliding-block.

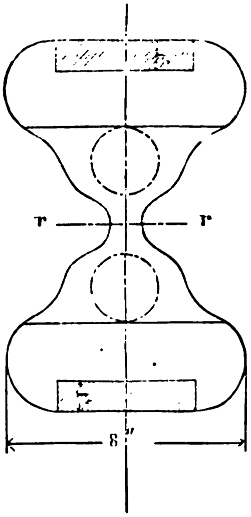


FIG. 114*a*.—Double sliding-blocks.

After the mold is put together, as represented in Fig. 115, and the proper wedging and propping done, the piece of metal to be pressed is put in,

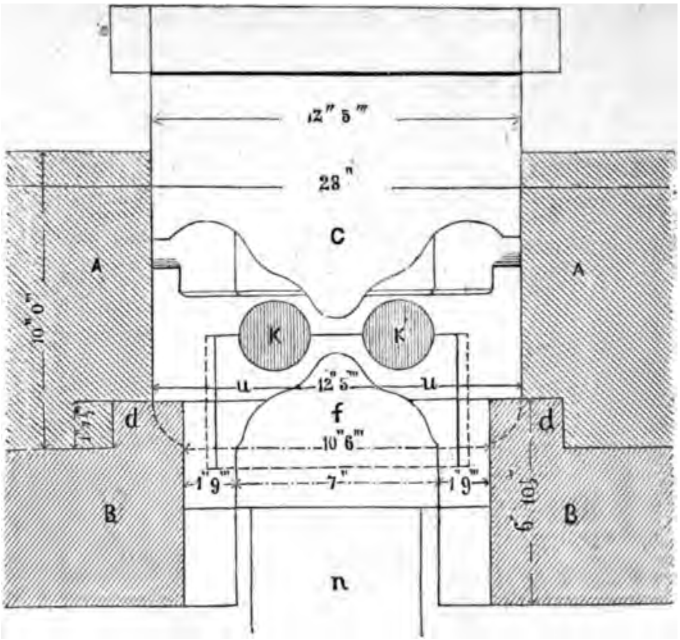


FIG. 115.—Mold for sliding-block.

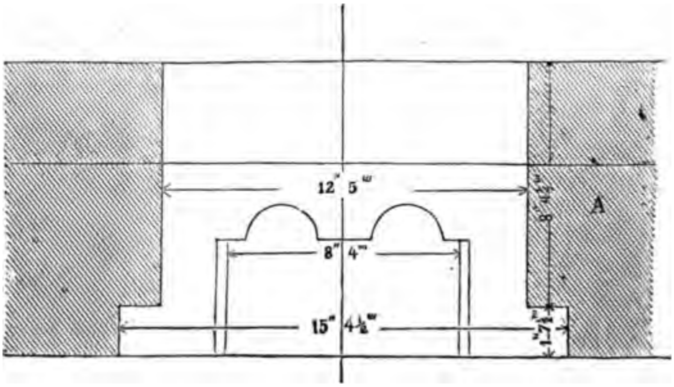


FIG. 116*a*.—Upper part of mold.

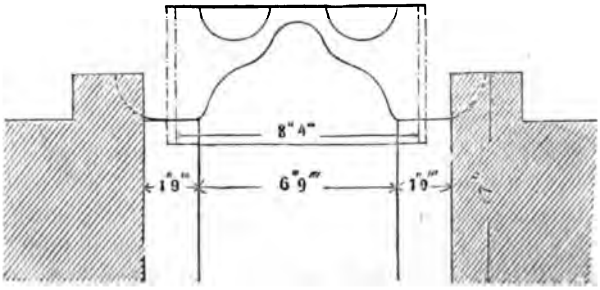


FIG. 116*b*.—Section on *b c* without *f*.

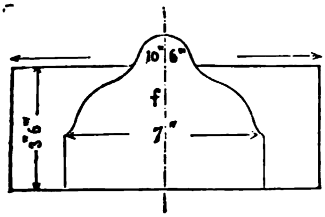


FIG. 116c.—Side view of *f*.

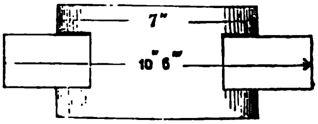


FIG. 116d.—Plan of *f*.

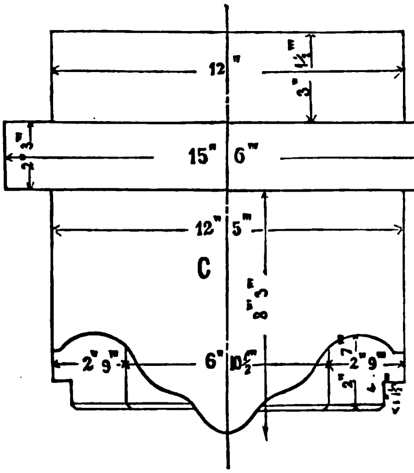


FIG. 116e.—Stamp or die.

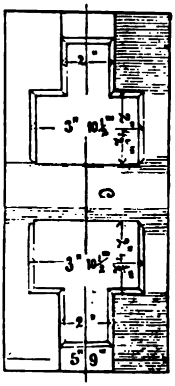


FIG. 116f.—Plan of the die.

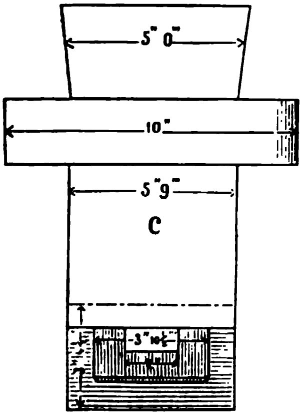


FIG. 116g.—Side view of the punch.

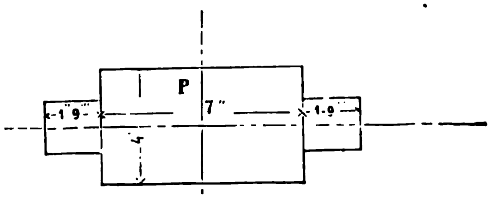


FIG. 117.—Top view of punch.

after being heated, as before mentioned. At a single stroke the piece is pressed. The die C is then raised, the side-piece *f* is removed by simply knocking away the prop *n*. The punch P (Figs. 117 and 118) is now placed in the impression already made by the die C, and pressed through. The wedges and props are then removed, the upper part elevated away from the lower, and then let down upon it again after laying some blocks between the two. The stamp Q (Fig. 119) is then placed upon the piece, and a gentle pressure frees it from the mold. The piece is then sawn in two and finished. By employing two furnaces, from twenty to thirty of these sliding-blocks can be made in ten hours. Figures 134 to 138, page 273, further illustrate the process.

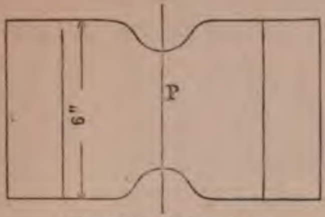


Fig. 118.—Side view.

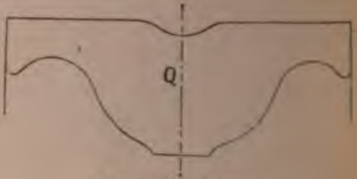


Fig. 119.—Stamp.

182. CYLINDER-HEADS.—The manufacture of cylinder-heads of wrought iron by pressing is very similar to the forging of the same with steam-hammers, by swaging, but the difference in the expense of manufacture is very considerable.

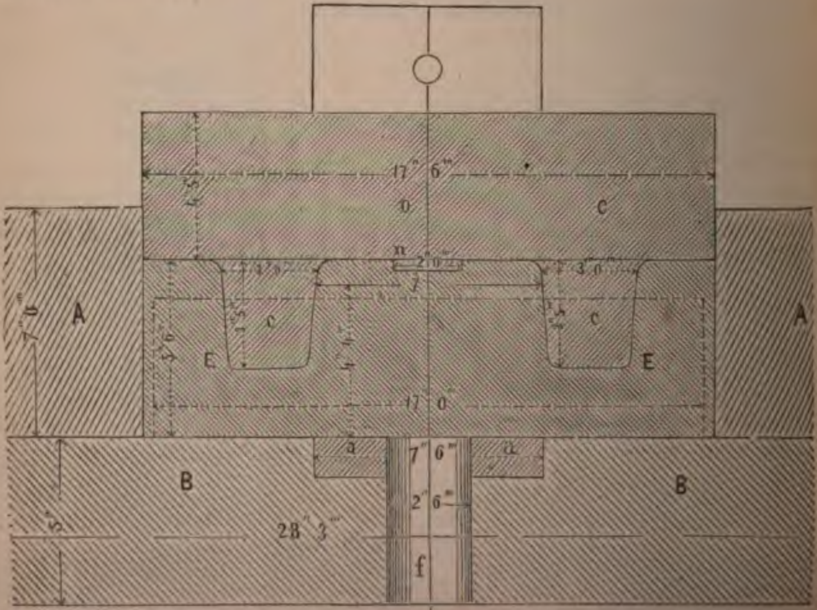


FIG. 120.

The bloom is made as before described, 260 pounds being required for one head. This piece is hammered under a steam-hammer of 80 hundred-weight until it has a thickness of 4½ inches and a diameter of 17 inches. Four pieces are placed in the heating-furnace at a time.

The cast-iron mold in which it is pressed is represented in Fig. 120. It consists of two parts, A and B, and the stamp C. Fig. 120 shows the mold as it appears when the cylinder-head is pressed, but not yet punched. E E represents the piece as placed in the mold before pressing. *A A* is a block of cast steel, which is put in the bottom of the mold so as to give a harder edge, which will better resist when the hole is subsequently punched.

After the cylinder-end is shaped, the die C is raised and the ring *n n*, Fig. 121, is laid on the surface of the piece to prevent it from splitting; then the punch, of 2 inches in diameter, is placed in the impression made by the die and then pressed through.

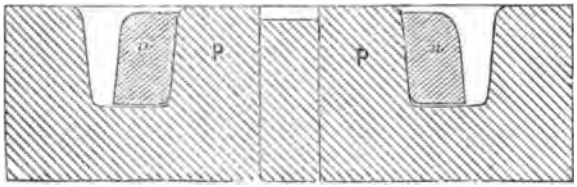


FIG. 121.

The piece is separated from the mold as in the case last described.

From 20 to 25 of these pieces can be made in ten hours, with two furnaces, one for the hammer and one for the press. Another mold would, of course, double the production.

183. LOCOMOTIVE-WHEELS IN SOLID SEGMENTS BY PRESSURE.—The manufacture of the parts of wheels by the process of pressure enables the manufacturer to make segments with two or three spokes; and this process, in point of economy, strength, and beauty of product, has great advantages over the ordinary methods. A wheel with ten spokes, when made by the common methods, consists of twelve pieces; but when made by this process it is composed of but four pieces. We will give here only a description of the manufacture of the most complicated part of the wheel; that is the part with the crank-pin, as the other parts are made by a simpler repetition of the same process.

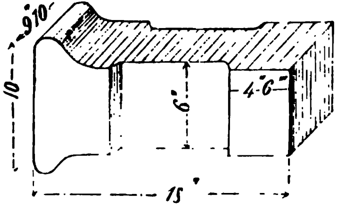


FIG. 122.

The manufacture of the segment of a wheel from wrought iron.—The bloom is made in the ordinary way, from scrap-iron, and has a weight of 250 pounds.

The bloom is forced under a steam-hammer (60 cwt.) into a parallelopipedon 16 inches long, 11 inches high, and 7 inches wide. While still warm it is put into the heating-furnace, and when very hot, is forged with the steam-hammer into the form shown in Fig. 122. The piece is then replaced in the heating-furnace preparatory to pressing.

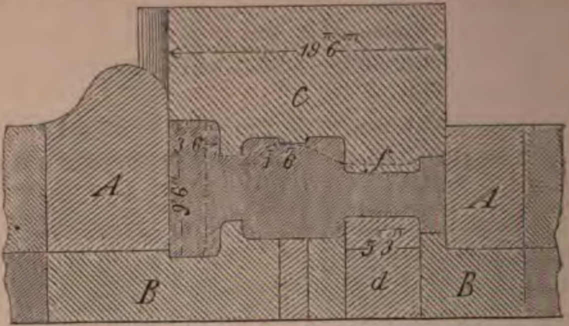


FIG. 123.—Vertical section through mold.

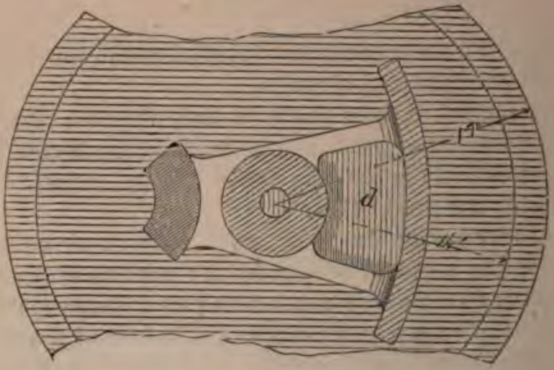


FIG. 124.—Lower mold B.

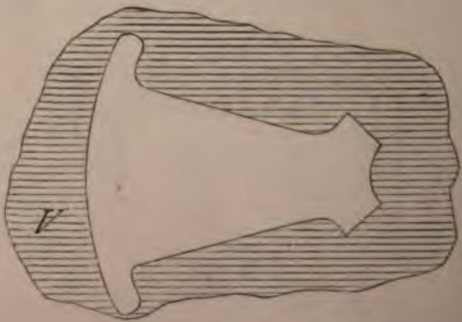


FIG. 125.—Mold A.

The piece is pressed in the cast iron mold, (Figs. 123–125.)
sists of the upper mold A, the lower mold B, and the die C.

ıe punch *d*, which is seen in the lower mold, is kept in position brace. The outline of the die *C* is like that of the bottom of the l, but with the addition of the shoulder *f*, which makes an impres-

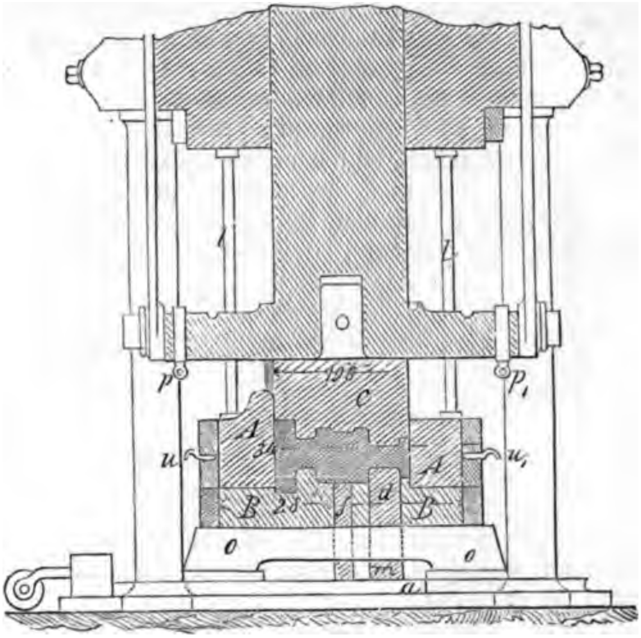


FIG. 126.—Wheel-segment in press.

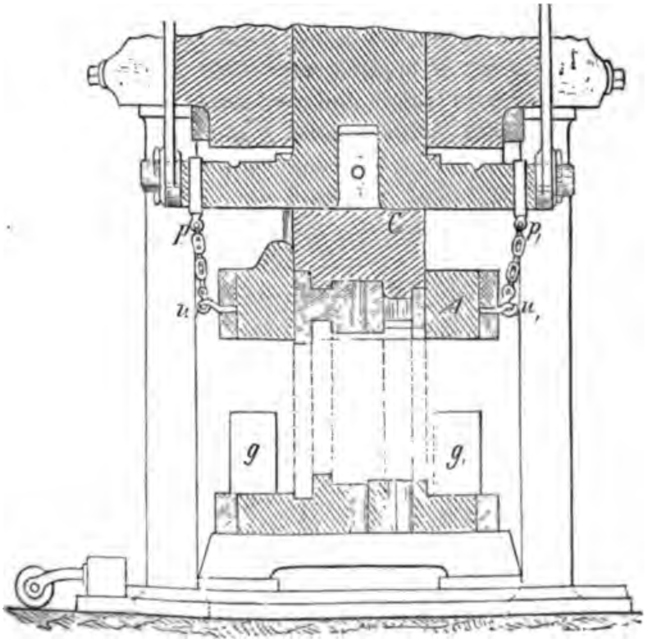


FIG. 127.—Vertical section through press and mold.

sion to guide the subsequent perforation. The mold stands on a bed-plate, O, (Fig. 126,) on which it can slide either to the right or left as desired.

When the mold is fixed in the proper position, and the braces *ll* are fixed so as to hold it there, and the mold thoroughly greased to facilitate the removal of the form, the piece (Fig. 122) is placed in the mold, being from the heating-furnace at a strong welding-heat. Now follows quickly the action of the press, by which the piece is shaped as shown in Fig. 123. The die *c* is now raised, and a punch corresponding in shape to the piece *d* in the lower mold is placed upon the impression made at *f*. The piece *d* is then removed by knocking away the brace, and the piece is perforated, thus forming the spokes. By a similar process the hub is formed. The piece is removed from the mold by the same general process before described, by raising the upper part of the mold and gently forcing the piece out.

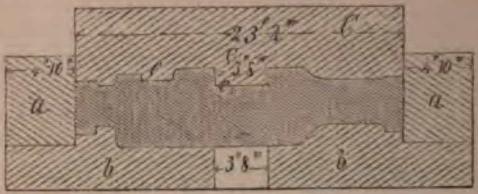


FIG. 128.—Section through mold.

With two furnaces twenty-four pieces are produced in ten hours. The expense is from 30 to 35 per cent. of the cost of forging the same under a steam-hammer.

The making of smaller wheels in one solid piece is, of course, only a repetition of the process of making segments. The whole wheel is first pressed and the spokes indented, and the interspaces afterward punched out. It may appear that there is a great waste of material in the process of pressing; but it will not be forgotten that every scrap is again used, and therefore no objection of this kind can be urged against this very important process. Figs. 128–130, inclusive, further illustrate this process.

184. LOCOMOTIVE-CRANKS OF WROUGHT IRON.—The bloom made in the same manner is forged into the shape represented in Fig. 131. It is then reheated in a furnace that will hold three such pieces of from 340 to 450 pounds each. The mold is shown in Fig. 132.

The pressing is quite simple. After the mold is braced, the shaped and heated piece is put in and receives the pressure. It will be easy to see that the iron is forced to flow into the die for the formation of the pin, as also the other parts of the mold. This flow necessarily creates a fiber which will run parallel with the pin, and will therefore be theoretically correct. The same will be the case with the body of the crank and the shoulder for the axle, since the crank is made considerably shorter than the mold. After pressing the crank a punch is placed on

indentation at *g* and pressed through after removing the piece *f* from ler the mold.

'wenty cranks can be produced in ten hours, at from 13 to 14 per t. of the cost of cranks forged under the steam-hammer.

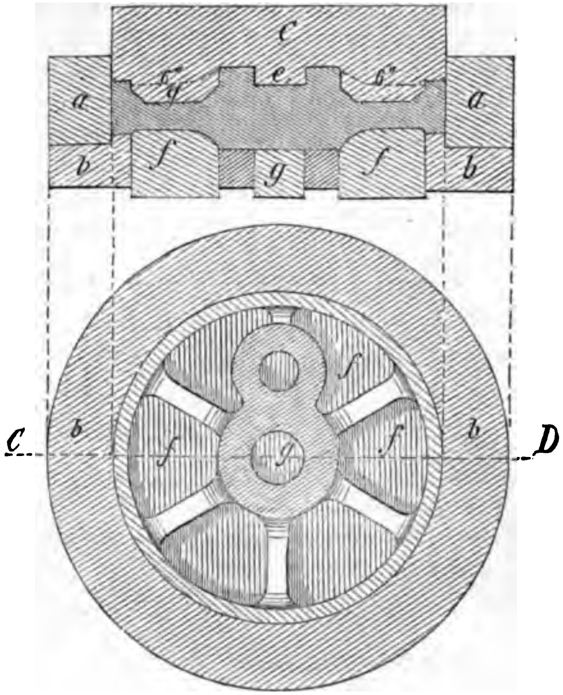


Fig. 129.—Lower die.

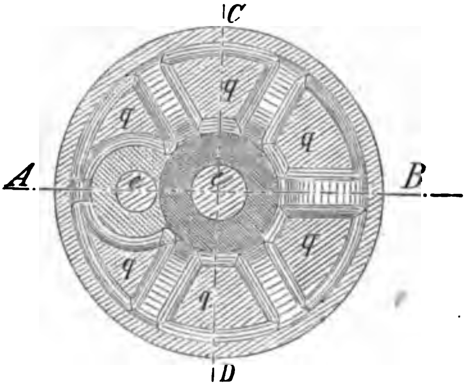


Fig. 130.—View of die from beneath.

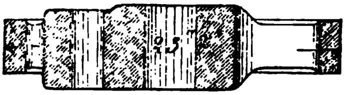


FIG. 131.—Locomotive-crank, first stage.

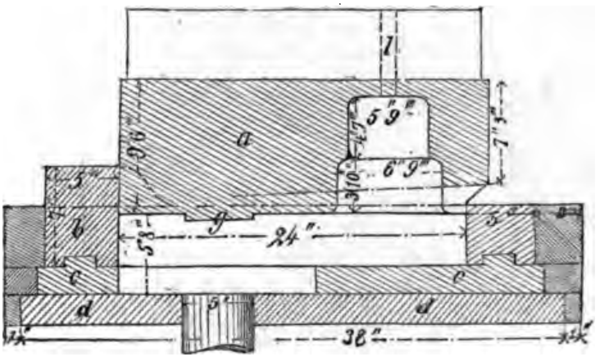


FIG. 132.—Vertical section through mold.

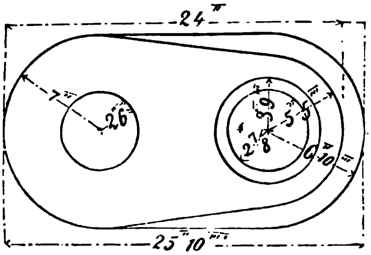


FIG. 133.—Crank.

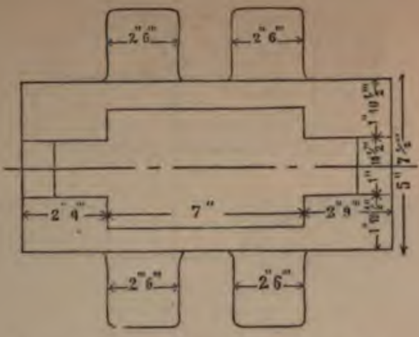


FIG. 134.—Mold for sliding-block plan.

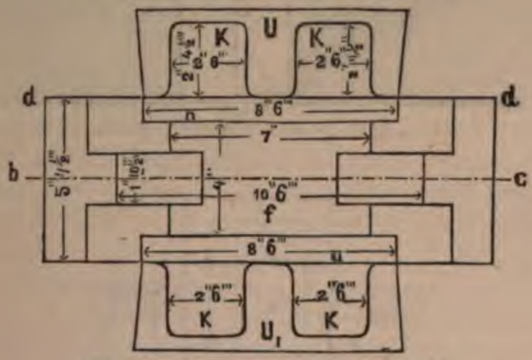


FIG. 135.—Plan of lower part of mold.

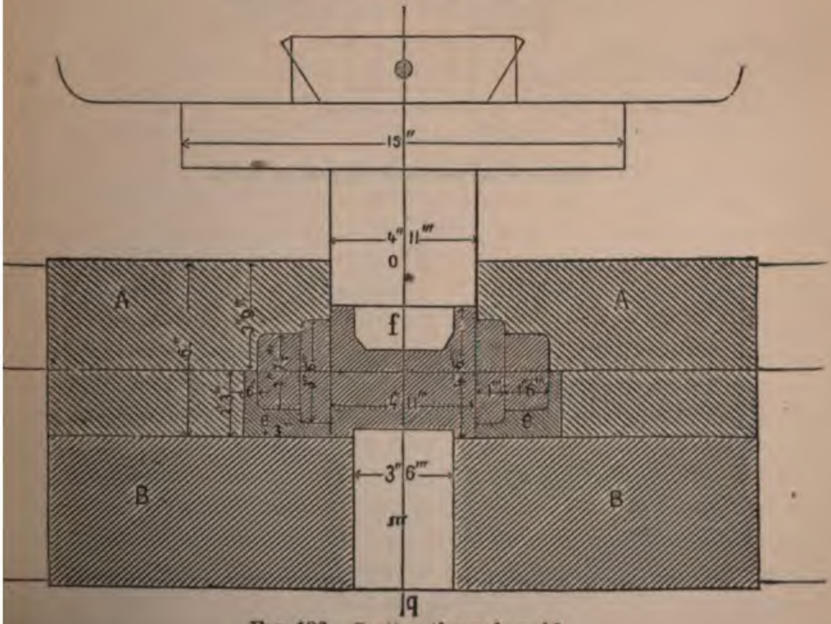


FIG. 136.—Section through mold.

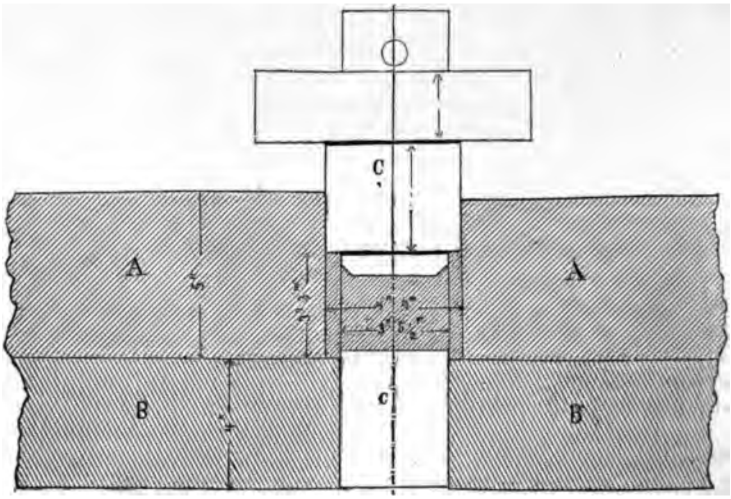


FIG. 137.—Section of mold and die.

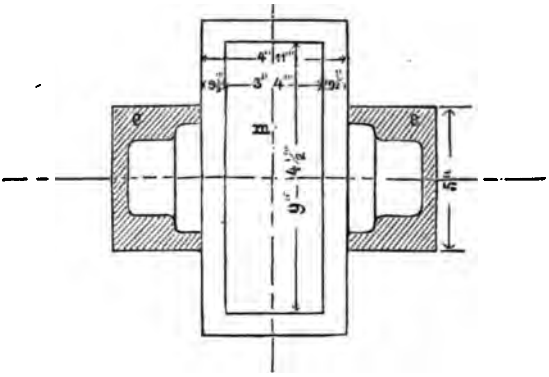


FIG. 138.—Plan showing part of mold.

CHAPTER XI.

IRON AS A MATERIAL FOR ART-WORK.

Numerous examples in the exhibition of the use of iron in artistic manufactures; Iron castings; Forged railings and gates; Damascened work of Spain; Repoussé work, Elcho Shield; English-made gates and railings; Cast-iron reproductions of art-objects; Ilsendburg foundery; Molding-sand; Quality of the iron used; Proper selections and mixtures.

185. This report would be deficient to a greater degree without at least a passing notice of the wealth of examples throughout the Exhibition of the use of iron in artistic manufactures. We find it in almost every section, either cast or wrought, in wire or in burnished steel. In the form of castings, we have the groups of life-size figures of men and animals, the exquisite bas-reliefs and reproductions of mediæval armor, and of the patiently executed *repoussé* work of gifted sculptors, sent by the Ilsenburg foundery, in the Harz.

For forgings we have only to turn to the splendid gilded gratings filling the spaces between the columns of the rotunda; to the entrance-gates of the jury pavilion; to the gates and railings inclosing the house and grounds of the British commission; to the examples of mediæval gates in the British section; to gates and floriated ornaments in the Belgian and Italian sections; and, finally, the railings of the Russian court.

The damascened work of Spain also challenges our admiration, particularly the objects shown by Placide Zuloaga, of Eibar, consisting of inlaid and carved iron, damascened caskets 6 inches long, 3 inches wide, and 4 inches high, for $250; buttons, shawl-pins, match-boxes, mirror-frames, platters, &c. The largest object is a shield of damascened iron, valued at $1,200. This industry appears to be reviving, and the artist has established agencies in London.

For *repoussé* work, the most notable example is found in the brilliant display made by the Elkingtons, of England. Here we find the famous Elcho volunteer challenge shield, presented by Lord Elcho to the volunteers of Great Britain, to be given over annually to the successful competitors at the great Wimbledon tournament. The shield is held in trust for this purpose, and was loaned to the Messrs. Elkington to exhibit by the trustees. This is the largest work in *repoussé* iron ever manufactured in England. It is 6 feet high, and in the mediæval style of art, from a design by F. Watts, R. A. Iron was selected as the material, because it does not tempt the cupidity of any one, and thus endanger its destruction. The workmanship, and not the material, constitutes the value. The shield, which in general has the Norman form, has a hexagonal center-piece in the upper portion, bordered with a girdle, at and upon which is the inscription, "The Elcho Challenge Shield, A. D. 1862." A medallion portrait of Her Majesty the Queen is suspended from this, and occupies a central position. Above and within the space inclosed by the band there is a group representing Britannia. The crown and royal arms occupy the projecting points above and at the side. Upon the dexter side there is a representation of Queen Elizabeth reviewing her troops at Tilbury, and opppsite to it Queen Victoria opening the volunteer competition at Wimbledon by firing the first shot. There are also representations of the battles of Bannockburn, 1314, and of Flodden Field, 1513, whilst at the foot two large-sized figures typify the close union now existing between the English and Scotch. A border of thistles and roses in high relief completes the idea.

186. **WROUGHT GATES AND RAILINGS.**—In the Italian section we mention particularly the wrought-iron gates and railings sent by Pasquale Franci, Rome, decorated with bunches of grapes, grape-vines, and leaves, even the tendrils all wrought with singular fidelity and beauty.

In the British section, aside from the Elkingtons' work, the principal exhibitor of art iron-work is the Coalbrook Dale Company, Shropshire, which makes a specialty of entrance-gates, fencing, verandas, balconies, railings, fountains, vases, &c. They exhibit two lengths of railing on either side of the north entrances to the British section, and a grand entrance in mediæval style, consisting of a pair of wrought-iron entrance-gates, two hand-gates, four pillars, and short lengths of railing to match, executed by the company from designs by B. J. Talbert, esq. The enrichments are of cast iron applied, and the twisted bars are produced by Tuddenham's patent process.

The gates, railings, gas, pillars, &c., inclosing the house of the royal British Commission, namely, the principal entrance of cast-sheet fence and gates, terminated by two gas-pillars; the two lengths improved cast palisade fence on either side; a length cast-sheet balcony-railing on east side; the west entrance to the building, of patent twisted angle-bar fence and gates; a length of the same fence, of various designs, on west and north sides; a length of bracket-railing on east side, within the grounds.

Various coats of arms and trophies in and about the house of the royal British Commission.

Various garden-chairs in grounds and park, namely, "Osmunda Regalis," "Water-Plant," "Mediæval," "Midsummer Night's Dream," "Nasturtium," "Horse Chestnut," "Medallion."

Various vases, &c., in grounds and park, namely, "Milton," "Night and Morning," "Classic," "Jardinière," various flower-stands in grounds and park.

CAST-IRON REPRODUCTIONS OF ART-OBJECTS.

187. **ILSENBERG FOUNDERY.**—The castings from the celebrated Ilsenberg Foundery are shown in great variety in a special installation

made of iron in one of the large buildings erected by Germany. Here are to be found reproductions of ancient armor, such as breast-plates, helmets, shields, sword-handles, &c., besides bas-reliefs, caskets, tazzas, and small objects for ornamental purposes. All of these objects are characterized by great sharpness of detail, smooth surfaces, and a higher degree of finish than is usually found in iron castings. The prices, also, are very moderate. An interesting history of the establishment and a technical discussion of the quality of the materials used, appears in "Engineering," and is appended.

COUNT STALBERG WERNIGERODE'S IRON-FOUNDERY AT ILSENBERG, HARZ.*—The Ilsenberg Iron-Works are among the oldest in Germany, and the iron-foundery there is most probably one of the earliest in the world. In ancient documents written in the fifteenth century pots, plates, balls, &c., cast at Ilsenburg, are mentioned; while cast-iron plates, which have been collected on the spot for some time past, afford additional evidence on this point. The director of the Ilsenberg Foundery, Oberhütten, Inspector Schott, has collected and arranged these plates in his official residence, and the collection possesses much interest, not only from an historical, but also from an artistic point of view. All these plates have served as stove-plates, and almost all are marked with a date, the earliest being that of the year 1509. The subjects on the plates are chiefly taken from the history of the Bible, and the ornaments consist of busts, tournaments, and allegorical pictures. The latter begin with the commencement of the seventeenth century. Some of the older plates are very beautiful, and the whole collection proves in the best possible manner the great perfection and the high position German art must have occupied in the sixteenth century, how it declined gradually during the thirty years' war, and how it finally died out utterly during the eighteenth century.

If the earlier time shows, however, the most originality—for instance, Judith in the tent of Holofernes, surrounded by guns and gabions—the design of the figures, dresses, &c., is, nevertheless, so satisfactory from an artistic point of view, that the pattern-makers of that time who had carved the models, some of which are still at the stores of the foundery, must have been men well skilled in their art, and must have attained a degree of perfection which has never been since reached. But the success did not rest with the skill shown in the pattern, the molder using the pattern evidently participated in it, otherwise such fine castings could not have been produced.

With the decline of skill in making the patterns the taste naturally became corrupted, and the molding less and less perfect, until eventually it lost all artistic value; even in the beginning of the present century the art of molding was still in a very primitive state. When the taste for artistic design began to revive, the hands, still rough and unskillful, were led to better and higher-class productions, which elevated the taste.

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* From "Engineering," 1873.

When the appreciation of elegant forms shall have become general, then, and only then, we shall have in all branches of industry products equal to those of the sixteenth century, and the debased taste, now too common, will gradually disappear.

The necessity of extending art to all departments of industry occurred, nearly forty years ago, to Mr. Schott, who was at that time engaged on the Brunswick Works, the Carlshütte, and the Wilhelmshütte, both works being still famed for the excellency of their foundery productions. He is now, and has been for thirty-five years, the managing director of the Ilsenberg Foundery, and from the first he sought to cultivate art in the productions of the works. The results of his exertions in this direction are shown by the exhibits of castings of works of art in the German annexe for art and industry at the Vienna Exhibition.

The Ilsenberg Foundery exhibits at the Vienna Exhibition art-castings, which represent chiefly objects of the Roman period, of the Middle Ages, of the Renaissance period, and generally of such well-known works produced by master-hands as are most suitable for reproduction in iron. They are worthy of all praise for the clearness of the castings, and especially for beauty of form. They are not only suitable for decorative purposes, but they are very instructive.

It is unfortunately but too true that the want of appreciation has caused numerous works of art to be destroyed. Even in the first half of this century it has happened that ancient church-vessels have been sold by the authorities for the value of the metal for remelting. Such vandalism, however, is now no longer possible, and objects of art are sought for and carefully preserved. How much art-education has progressed in this direction has been fully proved by the many collections which have been made during the last few years. With refinement of taste increasing demands are made on precision and correctness of execution, and public taste has become greatly refined. Imitations and reproductions of antique works of art are no longer accepted as the simple copy of the outer forms, but an execution is demanded which should exactly represent the original in the smallest detail.

In consequence of the scrupulous exactness with which the old masters executed their work, and which did not admit of neglect even in the smallest and least important detail, great difficulties are met with in the reproduction of such works of art—difficulties which are especially great in iron castings on account of the impossibility of the parts being united by soldering. But notwithstanding these disadvantages the problem has been solved, and that in such a manner that iron castings may be substituted for electrotype productions, combining, as they do, greater strength with equal fineness, and, being cheaper, they should certainly be preferred. These are results which have been achieved through continued exertions with the view of cultivating pure art in the production of iron castings, and it is very desirable that these exertions should be continued by future iron-founders.

With regard to the process of production, it may be observed that the two main points upon which the casting of iron depends are the molding-sand and the metal. About three or four hundred years ago the conditions for preparing the sand required for casting upon the open hearth must have been known. It must even then have been recognized that the molding-sand should allow the penetration of the expanding gases, which are produced by the high temperature when the fluid metal is poured into the molds. Otherwise the fine castings already referred to could not have been produced. This condition of the molding-sand was far better understood in this remote period than at a later time, when an empiric preparation of the sand was considered to be sufficient, and by which means progress in the art of casting was necessarily hindered. When the question had to be decided as to what was to be done to improve the sand, especially for the production of sharp and fine castings, it is probable that a greater degree of fineness was tried. Unfortunately this condition of great fineness, which is decidedly necessary for sharpness in the castings, was accompanied by the disadvantage that the fluid metal, when poured into the mold, did not remain undisturbed, but destroyed the work of the molder. The problem was to find an explanation for these occurrences, and an acquaintance with the principles of the open hearth doubtless led to the conclusion that the want of penetrability, produced by the great fineness of the sand, caused this disadvantage. Nature rarely supplies a molding-sand which possesses both fineness and penetrability, and the general scarcity of such a sand, which induced many important iron-founderies to obtain it at great expense from distant places, naturally led to artificial productions being tried. We shall explain next the experiments made for producing an artificial molding-sand, and the results obtained.

188. MOLDING-SAND.—Of the various kinds of molding-sand at the disposal of the Ilsenberg Foundery, one is found in the neighborhood, in the diluvial formation, this sand consisting of a mixture of fat loam with coarse grains of quartz. It is used only for the molding of large pieces, and the molds made of it can be employed only after having been dried at a high temperature. A rather finer variety of this sand serves, when mixed with other sand, for larger class castings; but in this case, also, it is necessary that the prepared parts of the molds should be dried or heated in order that by the evaporation of the water there may be produced a contraction of the proportion of clay which the sand contains, and that thus there may be formed the minute channels which are necessary for the escape of the gases and steam generated at the high temperature of the fluid iron.

In the chalk formation, which fills the large and, in some places, deep basin adjoining the mountains of the Harzer district, there are found in the neighborhood of Ilsenberg, upon the chalky marl, strata of loam mixed more or less with grains of quartz of different degrees of fineness; the penetrability, and thus the utility of the molding-sand depending upon this admixture. In a few exceptional places there is found a molding-sand that could almost be used in its natural state; the quantities thus obtained, however, are very small, and are not in proportion with the increasing demand of Ilsenberg Foundery. If, therefore, the artificial preparation of the molding-sand had not been successfully introduced, the necessary supply could only have been obtained from distant sources at great expense.

After having recognized the penetrability of the sand for steam and gas as the chief characteristic necessary, it became next an important matter to determine the signs of this required penetrability existing, and for this purpose the following process has been adopted: A known peculiarity of a sand which allows of a casting being made in it without the mold being artificially dried, is, that if the molder moistens the mold with water, the sand possesses the surprising quality of absorbing the water without altering the mold. The molder can thus, when working with the so-called green sand, employ water according to his requirments, in order to strengthen the sharp corners, edges, and ribs of the molds, for which purpose water may be dropped upon the latter by means of a brush. The water disappears, and is absorbed without doing any damage to the mold. This quality of the sand has been used at Ilsenberg in the following manner for determining the penetrability of the material. After various mixtures of sand have been prepared, and after it has been ascertained that sharp and distinct impressions can be taken with the materials, equal-sized balls or cubes are formed by compressing the sand in the hand, and that to such an extent that a slight further compression is just possible; this is easily done with a little practice, as this manipulation forms an important factor in ascertaining the quality of the sand for all molders, and determines the degree of moisture to be given to the molding-sand for casting in a green state. The balls of sand thus prepared, and made of uniform size, are then weighed, and water is next poured upon them as long as it is absorbed. When absorption no longer takes place, and the water appears to remain on the surface of the sand, the balls are weighed again. Supposing the different samples to be equally good, as far as the power of producing sharp impressions (as previously ascertained) is concerned, then that sample which is capable of absorbing the largest amount of water will offer the greatest facility for the escape of the gases and steam.*

It was in 1844 when, by the kind recommendation of the director of the Ecole des Mines at Paris, M. Le Play, the Professor Gaultié de Chaubri obtained for several professional men admission to some of the founderies of Paris. Excellent molding-sand was to be found there, and the qualities which it possessed, necessary for the production of good castings, could be studied. The experience gained from the continued casting of bronze works, which could be applied to iron castings, and the great advantage possessed by these founderies of having to work only for specialties, and of not having, like other founderies, to change the class of work to be done every day, exercised a great influence upon the gradually improved preparation of the suitable sorts of molding-sand.

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*It should be mentioned here, that, in examining the sorts of sand, care has to be taken that the latter does not contain lime, which is often the case when the sand is found to lie on marl, and the greatest care should be taken in obtaining it. The burning of the lime, which takes place at the high temperature of the iron, forces the carbonic acid to escape, disturbs the fluid iron, and prevents the exactness and clearness of the casting. It is well to examine the amount of carbonic acid contained in the sand before using it, by pouring acid upon it.

Even in Paris it was impossible to get from natural sources a sand that would fulfill all requirements, although remarkably good sand is easily obtained there. Only a few districts of England and Germany participate in this advantage, and the neighborhood of Halle-on-the-Saale and of Walkenrind, in the Harzer Mountains, should especially be mentioned in this respect. It thus became necessary, even in Paris, to prepare good and useful sand by artificial mixture. Four different sorts of sand, two of a reddish and two of a grayish-yellow color, were found to be applicable for casting in green sand. A variety of sand similar to the latter was found in exceptional instances in the neighborhood of Ilsenberg, but, as mentioned already, it could only be obtained in an insufficient quantity, and not of quite as good quality as that found at Paris. Comparing the Ilsenburg sand with the samples obtained from Paris, it was found that the former was deficient in the contents of fine grains of quartz, whence its penetrability was not the same as that of the Paris material.

The treatment above referred to of the sand consisting of a mixture of fat loam and coarse grains of quartz, the insufficient penetrability of which had to be increased by continued drying or roasting, had to be applied also to the fine sand, and it had to be ascertained whether the deficiency in the contents of grains of quartz could not be replaced by the roasting of a part of the denser sand, which was consequently exposed to such a high temperature that the yellowish-gray color was changed into red. The mixture of this roasted sand with the original yellow-grayish sand in its natural state, gave the desired result, and the roasted sand was found to be a perfect substitute for the grains of quartz in which the natural sand was deficient. In order to make, however, this artificial mixture equal to the natural sand, a careful treatment was necessary, and for this purpose stamping-mills and revolving drums of oval section, containing loose balls, were adopted for the powdering and mixing of the sand. These drums have a diameter of about 3½ feet and a length of not more than about four inches, while the speed of rotation is arranged in such a manner that the balls are not so acted upon by centrifugal force as to prevent them from remaining at the bottom of the drum, or they would not exercise the necessary pressure upon the sand, which is put into the drum through an opening at the side. In order to obtain the required fineness of the sand, the passing of it through fine-meshed sieves becomes necessary, and for this purpose bolting-cloth made of sheep's wool, and known in Germany under the number 16, has been found best.

A fine molding-sand applicable for most castings in green sand was thus successfully produced, but the finer and better sorts of a reddish color, seen and found at Paris, which possess an extraordinarily high amount of penetrability, and which, moreover, allow of the cleanest and sharpest castings being made, were still wanted. It had been especially observed that the castings in this sand, which was even moistened to a great extent, remained unusually undisturbed, and it became, of course, a natural necessity to possess a molding-sand of equal quality.

At first an endeavor was made to discover such a sand in a naturally loose state, and it was thought that it might be found in the intermediate layers of the colored sandstone formation met with on the outskirts of the Harzer Mountains. All the sand, however, that could be found in a loose state in these strata contained too much clay for the required penetrability. Even after roasting it was found to be useless, because it had lost all its binding power, and attention was then directed to the solid sandstone, which, when ground, was expected to supply material of the necessary quality. The experiments made with these solid stones showed such a great penetrability that the best results could be obtained. The experiments with water pointed, fortunately, to a certain class of stones which had to be rejected for building purposes on account of their extraordinary hygroscopic qualities; these latter, however, justified great expectations for the molder—expectations which have now for many years been fulfilled. The mixture of the sand obtained from the stone, with the yellowish-gray sorts of sand mentioned above, has produced an exceedingly suitable molding-sand, the molder having it in his power, by adding more or less of this ground stone, to vary the quality of the material in accordance with the requirements of the work he has in hand.

The knowledge of the proper molding-sand required for a given pattern is the best proof of the ability of a molder, and such a knowledge can only be acquired by extended practice and correct advice, which latter, however, is unfortunately very often wanting in founderies producing inferior work. The importance of the correct preparation of the sand is in general little appreciated, and so long as no proper attention is paid to the requirements of a good molding-sand, and as long as there is wanting a correct understanding of the required penetrability in connection with a consistence of the material sufficient for the finest impressions, iron founderies will turn out works of art which could not be appreciated by eyes which have had opportunities of getting acquainted with more perfect productions.

From what has been said above, it will be found that the excellence of the molding-sand to be used does not depend so much upon the chemical composition, but rather upon the mechanical and correct mixture of the argillaceous and siliceous components. If the chemical investigations made in Paris and London with the small parts of molding-sand that remained at those places on the castings exhibited by Ilsenberg had been ever so carefully performed, they could scarcely have led to the preparation of a suitable molding-sand, which depends simply upon the shape and size of the added grains of quartz, and the plastic qualities of clay.

In the course of years a special custom has often taken root in founderies, in consequence of which most extraordinary results are often produced. The practice acquired in the manipulations can go so far, for instance, that a sand possessing a very small amount of binding power, but a high degree of penetrability, as often found in nature, is used with the best results. The ability acquired to produce fine castings in a loose sand, which gives way to the smallest shaking, which possesses only so much consistency as is required to withstand the pouring in of the fluid metal, and which combines the advantage that the larger quantity of grains of quartz prevents a burning of the iron, and produces better castings, requiring only little cleaning, is a great gain, which saves many expenses incurred by the employment of a molding-sand of greater binding power.

189. QUALITY OF THE IRON.—Art-castings in iron require for their successful production a carefully chosen metal, one which must not only possess greater strength than is required for ordinary castings, but one which, by its density and fluidity in a molten state, is capable of reproducing minute forms with sharpness and exactness. In order to obtain definite information as to the conditions under which suitable iron is produced by the smelting process, the material has, at Ilsenberg, been subjected to careful examination, both when in the fluid state and during the progress of setting and cooling; and these investigations, which have been carried on for more than thirty years, have resulted in the discovery of the facts of which we propose now to speak—facts which are of high interest in themselves, and which appear to us worthy of the most careful attention of metallurgists. Some time ago the writer of the present article called attention to the appearances which cast iron assumes during the fluid state, these appearances varying according to the proportion of carbon which the material contains, and even as long ago as 1867 we spoke in this journal (in an article entitled "The Berlin Castings," a name formerly generally used for art-castings in iron, but now almost abandoned) respecting these appearances. The matter did not, however, at the time receive from scientific men the attention it undoubtedly deserves, and we therefore propose to return to the subject, and discuss it more fully.

According to the appearance of the new fracture when broken, pig-iron is, and has been for many years, both in this country and abroad, designated by certain numbers, the particular value attached to each number varying, however, in different localities. Speaking broadly, No. 1 signifies a coarse-grained dark-gray iron; Nos. 2 and 3 are finer-grained and lighter grays; while beyond these come the "mottled" and "white" pigs. In many founderies in Germany the following scale is adopted: No. 1, largest-grained, highly graphitic, gray pig (*Gaares Eisen*;) No. 2, gray pig (*gaarflussiges Eisen*;) No. 3, mottled pig (*halbirtes Eisen*;) No. 4, strongly mottled pig (*stark halbirtes Eisen*;) No. 5, lamellar pig (*dünngrelles Eisen*;) No. 6, dead-white iron (*hochdunnes Eisen*;) and No. 7, white pig (*grelles Eisen.*) In this classification—which we shall adopt hereafter in speaking of the appearances of different classes of molten iron—Nos. 1 and 2 are varieties of gray iron, Nos. 3 and 4 of mottled iron, and Nos. 5, 6, and 7 of white iron.

If, now, an alteration in the working of the blast furnace or of the cupola shows that a change has taken place in the quality of the iron, or if it is desired to secure the success of a particular casting, the following observations may advantageously be made: Let a sample be taken from the iron available, and let it be cast in a semi-spherical mold, prepared as for an open-sand casting, but lined with finely-prepared sand, care being taken that the sand is neither too tightly nor too loosely pressed down. For making this simple casting, a small ladle and a straight-edge are carefully warmed, and the necessary quantity of iron is then tapped from the furnace or cupola into the ladle, the slag being removed with the heated straight-edge. When this has been done the iron is poured as quickly as possible into the mold, when the heated straight-edge is again passed over the iron. Experience has shown that when a furnace is working irregularly the various classes of iron above spoken of are sometimes to be found arranged one over the other, according to their specific gravities, and in procuring a sample, therefore, care should be taken to procure an average of the whole. The metal having been poured as above directed, the following observations should be made:

1. The color of the iron during the casting.
2. The movements which take place upon the surface of the metal immediately after pouring.
3. The state of the iron during and after its setting.

For the various classes of iron above enumerated these appearances will be as follows:

No. 1 *iron.*—This iron has during the casting a reddish-white color, and after running it remains unagitated, and has the appearance of a crystallized fat, while it presents a frothy surface covered with "kish."* Its fracture when cold is dark-gray, coarse-grained, glossy, and very soft, but when remelted it gets a finer structure, and becomes suitable for being recast in crucibles for the production of art-castings.

Another variety of this iron, during the pouring, has a lighter color than the variety of No. 1 previously mentioned, while, when cast, its surface is covered with a thick, dim skin, which during the experiment slowly separates in one direction in straight lines, showing at the fissures the bright metallic surface. After these movements have lasted some time, the dim skim again entirely unites, while the iron is seen to be still agitated, and commences to show small projections at those points where the division of the skin last occurred. After setting, the iron shows a slightly convex surface, which has a smooth glossy appearance, with here and there a sparkle of graphite.

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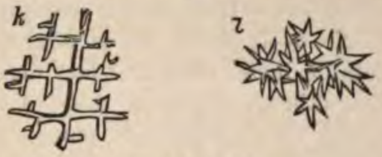
* For the difference between graphite and "kish," see a paper contributed by M. Ledebur to the *Berg and Hüttenmanischen Zeitung.*

This iron, when cold, has a dark-grey-glossy, fracture, the grains in the latter being the more strongly marked the greater the volume and strength of the casting. This class of material is well suited for the casting of fine works of art, as, when quickly poured, it fills the molds well and perfectly, possessing at the same time a great amount of softness. When less quickly poured, the separation of "kish" gives to the casting an objectionable appearance, similar to that of the first-mentioned variety after setting.

No. 2 iron.—This iron has, during the pouring, a dazzling-white color, while the dim skin which forms on the surface does not appear to be so thick as in the case of the class of iron last spoken of. As the iron runs from the ladle, a tearing-asunder of this skin and a display of a metallic glare below is observed, the surface at first splitting only in one direction, but fissures subsequently opening up in various directions, the following sketches, *k* and *l*, showing the chief figures formed. The figure *k* refers to a charcoal, and figure *l* to a coke, iron. These figures may often be traced even after the setting of the iron, they being then formed by projection on the surface. After the fissures on the surface have been drawn together again, the iron, which is still agitated beneath, evolves small bubbles of gas, which force their way to the surface, this being especially the case toward the middle of the mass.



Crystallization of iron.

With the exception of the points where projections mark the last fissures in the skin, the surface of this iron, when set, is dim, glossy, and smooth, and its appearance is similar to that of refined metal, this being the case even in the fracture, with the exception of a little lighter color and slightly denser structure. This iron is the best for art-castings, as the largest as well as the smallest articles may be safely cast from it, it giving clean and sharply-marked productions, which can be well worked on account of their but slight degree of hardness. If also the blast-furnace charges are good, and the varieties used in the cupola well chosen, iron of this class shows great flexibility and elasticity.

No. 3, or slightly-mottled iron.—This iron has, when poured, a light or white color, the skin being similar to that of the No. 1 iron, but thinner, while at the point where the flowing commences a stronger metallic luster appears on the broken surface. After the pouring has taken place, the iron at first, like that last mentioned, shows fissures in the skin extending in one direction only; but this merely lasts for a short time, a dividing of the lines then taking place, and cruciform fissures being formed for charcoal, and star-like fissures for coke iron.

This splitting up of the surface into fissures goes on very rapidly, new figures continually appearing only to disappear again and make room for others, the appearance being altogether a very interesting one, while the backward and forward movement in the material is remarkable. After this state of affairs has lasted some time the evolution of bubbles of gas commences, the bubbles being more numerous and being evolved with greater activity than in the cases formerly noted. During this period a great agitation of the metal occurs, this decreasing gradually until the iron is "dead," when it begins to set. The surface in this case is no longer rounded, but straight, and is covered with a number of small spheres, which show empty hollow spaces, and adhere very strongly to the surface, so that they cannot readily be removed.

The fracture of this iron shows a light color and slightly glossy surface, and is no longer strongly grained. The material is still suitable for art-castings, but the objects cast from it should not have thin places, as they could not be worked upon, and would require previous annealing. On account of its great density, however, this iron is well suited for castings which have to be bored or turned, and particularly for those on which polished surfaces have to be got up. The problem is to produce an iron of this kind with the peculiarity of not being inclined to chill; but this can be done by care in charging the furnaces.

No. 4, strongly-mottled iron.—If the iron is strongly mottled—approaching in character to No. 5—it shows, when poured, a brighter appearance and higher metallic luster than that last described. The fissures formed in the surface-skin are similar to those of No. 3, but the figures formed are smaller, and the changes take place more rapidly, so that a certain amount of practice is required to enable appearances to be fixed by the eye. The formation of the gas-bubbles also is more distinct, and their evolution commences at an earlier stage.

The setting of the iron takes place under conditions similar to those last described, but the surface becomes covered with numerous leaves covering larger or smaller concavities in the surface of the iron, according to whether the leaves have been formed by the combination of several bubbles, or by the adhesion of single ones. The surface is straight, and the fracture has a light, fine-grained appearance. Th iron cannot be used for fine-art objects, but it may be empl larger articles, which posses a certain degree of strength.

No. 5, or lamellar iron.—When poured, this iron (which

rded as a white pig) shows a light brilliant color, while the
vhich accompanies the breaking of the skin is greater than in
ieties previously noted. After pouring, a to-and-fro movement
fluid metal takes place, but this only lasts a short time, being
l by the formation of stellated figures, which change rapidly,
ich are like those sketched above. In this metal the figures
ller in size than those produced by the classes of iron already
of, while the bubbles of gas are more frequent, and of larger
er. These bubbles unite to form the large leaves which, being
cool more quickly than the mass of metal below, thus giving
face the peculiar appearance of a red-hot mass of iron covered
rk spots, this being especially the case around the circumference,
the cooling takes place earlier. This appearance is not much
founderies for fine work, as it signifies an iron suitable for heavy
s only, but especially applicable to some parts of machinery.
cture of this iron is lighter than that of the earlier numbers, and
s fine white patches, and a very dense grain.

, *or "dead-white" iron.*—The conditions just described are to be
also, to a great extent, in the case of "dead-white" iron; but the
on of the figures is in this case still more rapid, and the fluidity
iron is of less duration. The size and quantity of the gas-bub-
e also considerably increased, as is also the appearance of the
ots already referred to. The surface, too, when set, is no longer
t, but slightly concave, while, after the opening of the leaves
ed by the bubbles of gas, deep holes are seen. The difference
two classes of iron consists in the latter having not only deep,
o flat holes, the existence of these proving the iron to be of a
class than the other. The fracture of this metal shows a mixture
e and gray iron, this variety marking the transition to white
operly so called. If the proportion of grey and white is about
the metal is known on the Continent as "Forellen" iron. Such
no longer suitable for fine castings, but if produced by a well-
d charging of the furnace, it possesses a very close structure and
trength. This iron is especially suitable for casting large rolls,
gain in strength through their cooling very slowly, and which
subsequently turned. It is also suitable for the production
led castings, of which samples are exhibited at Vienna by the
erger Gewerkschaft, of Styria.

7, *white iron.*—The form of this iron in section when cold is con-
When poured, this iron has a white color, but this very soon
s to red, while the metallic luster is very strong. The splitting
ning up of the skin does not last long, but soon makes room for
rmation of large gas-bubbles, which may be observed violently
ng the mass. These bubbles burst, and the discharge of gas
place with such force that fine particles of burning iron are
out in all directions. The surface next begins to sink, and soon
skin begins to spread like a shadow over the surface

of the still red-hot mass, from the circumference toward the center. Finally this skin becomes lighter and peels off, showing a number of the shallow cavities described above. The fracture of this iron is white, and the metal is too hard to allow of its being worked.

The characteristic appearances of the various sorts of iron depend upon and are intimately connected with the proportions of silicium, manganese, phosphorus, sulphur, &c., which the iron contains. If, for instance, in an otherwise normal state of the iron, the contents of sulphur in the latter is proportionately large, the so-called "Bräunen," with the leaving behind of flat holes, may be observed. The shape of the figures due to the fissures in the skin is also altered if an addition of zinc, copper, &c., is made, and, for instance, the addition of tin causes these figures to alter their shape entirely, and gives rise to beautiful formations. It is often surprising how, for similar reasons, the iron, which, at the beginning of the observations described in our former article, showed a distinct characteristic, alters in its appearance suddenly and unexpectedly.

The formation of distinct figures by the division of the surface skin was formerly attributed chiefly to the inclination of the iron towards crystallization, but a closer knowledge of the composition of the iron has shown that the generation of gas dependent on this composition, and accelerated and acting through the presence of the oxygen of the air mixed with the metal by the act of pouring out, must exercise an influence upon the formation; this generation of gas being proved by the bubbles that rise and escape.

The question now is, whether conclusions cannot be drawn beforehand from these observations respecting the composition of the iron, and whether a preliminary determination of the contents of sulphur, phosphorus, carbon, manganese, &c., cannot approximately be made. How important these observations would be for the industry of iron if, as has not so far been the case, they could be connected with chemical analysis, and how much more instructive would they be if microscopic investigations of the crystalline formation could be added. The latter investigations certainly deserve more thorough study than they have hitherto received, a neglect which can only be explained by the difficulty of the observations, the lens necessarily having to be placed close to the surface of the iron that is under examination, and it thus being impossible to obtain a large field of view, a few particles only being in the right focus.

Long and continued study and practical observation have made the present writer acquainted with the treatment of iron in the foundery, and he is thus in the position to state briefly a few rules which may be useful for determining the suitable sort of iron for special classes of art-castings. The following statements are, therefore laid before the public, with the request of an indulgent and unprejudiced judgment.

In iron bars, which show after the setting hollow internal spaces, (such as must necessarily be produced in consequence of the setting growing from out to inside, if nothing is done for their prevention,) there are to be found in these hollow spaces octahedral crystals more or less beautifully formed according to the degree of fluidity of the iron. Now, notwithstanding the exact resemblance of the fundamental shape of the crystal, it will be found, if the various samples of iron are compared with each other in this respect, that *one* difference may be observed, namely, the different proportions between longitudinal and cross axes of the crystals. The more beautifully the crystals are shaped, the more clearly is this difference of proportion observable. Very large formations of crystals are often to be seen in the more capacious cavities of large castings, but these are seldom of such pure and delicate forms as those to be found in smaller cavities. If they are completely formed they resemble small fir-trees, as octahedral needles at certain distances, forming also an octahedral-like space, and will be found to have arranged themselves around a central axis.

By the aid of a powerful lens a similar appearance is to be found in the surfaces of fractures of iron which are more minutely examined, whilst even a smaller magnifying power shows the triangular surfaces of the crystals and their proportionately different longitudinal axes.

The same class of crystals is to be found in all kinds of iron and steel, and the similarity is often so great that the assertion might almost be made that cast iron is nothing else but a compound of bar-iron crystals and graphite, and that the quality of the cast iron depends upon the proportion and character of the mixture of these components.

Such an opportunity as is at present given at the Vienna Exhibition for the study and comparison of various sorts of iron is very seldom offered, and never again perhaps will such a perfect series of samples of iron and steel from all parts of the world be found collected together as at present at Vienna. Examining now these various sorts of iron, it will be acknowledged that to produce a certain class of castings, the pig-iron forming the charges of the cupola or melting-furnace should be selected and examined with the same care as the ores for the charges of a blast-furnace; but while in the latter case the nature and quality of the ores to be used are thoroughly investigated before being fed into the furnace, the iron for the cupola is but too generally examined only slightly and superficially, and a microscopic examination, which would offer some reliable data, is seldom resorted to. Instead of this, however, the quality of the iron is estimated from the place of its production, and if the nature of a certain brand of iron, supplied by known iron-works, has once been ascertained, it is generally taken for granted that all further supplies from the same works will have the same qualities. Where, however, (as is generally the case,) the charges of the blast-furnace are not always the same, the iron produced should be chemically, or at least microscopically, examined before being used in the cupola for the production of castings of a given quality.

This matter, which is of such great importance, has hitherto been so little or so seldom cared for, that the present writer desires to direct especial attention to his own experimental observations, in the hope that other professional men will also take some interest in the development of this important subject. The importance of this matter for the whole of the iron and steel industry will be distinctly seen in the diversity of the conditions of the various sorts of Bessemer pig after the changes in the different stages of the Bessemer process, and a comparison of the processes brought, at the Vienna Exhibition, before the public is highly interesting.

While, for instance, the gray Swedish Bessemer pig changes under the slightest treatment quickly at first into spiegeleisen, the Bessemer metal exhibited in the various stages of treatment by Ockhowo, Government Ekaterinoshan, (Russia,) shows, even in the higher stages of the Bessemer process, still some graphite. With respect to the foundery, the iron containing carbon in a fixed state cannot be cast well, (the appearance of the malleable cast iron should be considered,) nor does it allow of any working treatment, and is thus not so good as that (according to the opinion expressed above) consisting of a mixture of wrought-iron crystals and graphite; it is therefore of great importance for the foundery that a pig-iron should be used which has not the qualities of the Swedish iron, but that of the iron exhibited by Ockhowo.

It has to be considered that the iron, having become fluid in the higher temperatures of the ordinary cupola, has to pass in its descent through the current of air still saturated with oxygen, that it is subjected to an alteration similar to the fining process, and that it will become white and hard if the formation of graphite has not been reconstituted by the abundance of carbon. In connection with this matter we may mention the cupola-furnace invented by Herr Krigar, of Hanover, this furnace being constructed so that the molten iron is withdrawn from contact with the coke and blast, the hearth for receiving the iron being to one side of the furnace and not directly below the crucible as usual. When this furnace has been correctly put up, its use has always been attended with an economy of coke; but this is not its only advantage. A leading feature is the decrease of the danger of producing white and hard iron. Hence in a furnace on Krigar's system, a larger percentage of coke-iron may be added to charcoal-iron without producing a white metal than is possible under ordinary circumstances. In fact in Krigar's furnace a suitable metal for art-castings may be obtained by the use of coke-iron, although, of course, charcoal-iron is always to be preferred.

In support of the opinion that no iron having an inclination to get white should be applied for art-castings, we may refer to the fine iron castings exhibited by Rastorgonieff, of the Usines de Kischtim, near Perm, in the Ural, (Russia,) which have been produced by previously submitting the iron used for them to a trial in open sand-molds, when it was first determined that the iron would not get white, but would remain gray; if this was not the case it was not used.

It is further certainly erroneous to suppose that a large percentage of phosphorus, which tends to make iron become white, is especially advantageous for art-castings, and this opinion is only correct in so far that the normal working of a blast-furnace using limonite ores produces an iron free from "kish" or iron froth, and which is of a very fluid nature, penetrating sharply into every form, although it is hard and possesses the necessary strength.

This quality and that of other sorts of iron corresponds exactly with their point of fusion, and many occurrences, often of considerable disadvantage, depend upon it; among the most disadvantageous is, however, that of the so-called burning (*Anbrandes*) which shows itself by rough or file-like surfaces, which take away from the castings all fineness and exactness, and make them look imperfect and almost useless. A closer examination shows that these rough surfaces have been produced by the accumulation of small projections, which partly cover the casting, and with a certain thickness. This appearance is entirely independent of the molder's work, and if the latter has been executed as carefully as possible, and the best casting might have been expected, the surfaces are, nevertheless, covered with projections and grains. The reason for this can, therefore, only be in the quality of the iron. It has been endeavored to ascertain the reason for this chemically, and it is said to have been discovered that the projections forming the rough surfaces were special compounds of iron and other bodies. This, as will be seen hereafter, is correct; but it alone does not explain the mechanical processes that take place in connection with it. Our own opinion on this matter is as follows:

The iron in a fluid state will be no homogeneous body, but a composition of various compounds between iron and phosphorus, iron and sulphur, iron and manganese, iron and carbon, iron and silicium, &c. Each compound has, however, a certain point of fusion, the one lower than the other. Now if mixtures which differ much with respect to their point of fusion form the iron, one portion of the latter will set while the other portion remains in a fluid state, this latter part being forced by the contraction of the former portion through the pores, which are still open during the red-hot state of this portion of the iron, and in this manner the so-called burning or "*Anbrand*" is produced.

After having recognized this cause, it became possible to produce another sort of iron by other charges. The writer is able to show examples of iron upon which are to be seen small balls of the size of peas, in consequence of the great difference between the points of fusion of different parts of the metal. Many other similar occurrences might be explained in the same manner.[*]

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[*] Professor Gruner, in his article on steel, Annales des Mines, xii, vi serie, 4 liv. 1867, says, "From these results (various analyses of pig-iron) it will be seen that in the varieties of gray pig-iron rich in manganese the silicium is mostly combined with the manganese." Further: "The analyses show that the varieties of gray pig-iron must often contain more than 10 per cent. of foreign bodies, and that their number must be very considerable, &c.; even the white sorts of iron produced from spiegeleisen, which are acknowledged as being very pure, have, in reality, a very complicated composition."

190. A consideration of the facts above stated showing that it is desirable to possess some simple mode of determining the relative points of fusion of different classes of iron, Mr. Schott, the director of the celebrated Ilsenberg Foundery, some years ago devised the following method, which, although of course only capable of affording approximate results, he has found answer well in practice.

An iron vessel, weighing about 25 kilograms, is filled to a certain height with water, so that it contains exactly 48 kilograms. When fluid iron is poured in, the temperature of the water will increase in proportion to the temperature and the volume of the iron; and this increase of temperature is then applied for determining the relative points of fusion of the various sorts of iron in the following manner:

After having measured the temperature of the water, a portion of fluid iron, as taken from the blast-furnace or the cupola, is poured into it as quickly as possible. The water is then stirred, when the temperature is again observed. The water is now carefully tapped off, and the iron is taken out, dried, and weighed. The weight is thus obtained which at a certain temperature produced the observed increase of the temperature of the 48 kilograms of water. Various degrees of heat will produce various differences of temperature, but as it is not always possible to use equally large quantities of iron, while the results are in proportion to these quantities, the following formula has been found to give the relative weight for a certain degree of heat of the iron:

Let the quantities of water used in two experiments, carried out in the way above described, be represented by W and w respectively, and let also I and i be the corresponding quantities of iron used; T and t the differences of temperature produced in the water, and H and h the quantities of heat imparted to the latter per unit of weight of the iron. Then evidently

$$H :: h = \frac{W\,T}{I} :: \frac{w\,t}{i}.$$

But the quantity of water is constant, or $W = w$, therefore

$$H : h = \frac{T}{I} : \frac{t}{i}, \text{ or } H : h = T\,i : t\,I,$$

whence it follows that, if we give the result, H, obtained, in any one instance a certain standard value, the corresponding value of h, derived from another experiment, will be given by the simple formula:

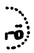
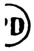
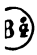
$$h = \frac{H \times t \times I}{T \times i}.$$

It is evident that H and h, instead of being expressed in pound-degrees of heat given out per unit of weight of iron, may, for practical purposes, be more conveniently expressed by the degrees of temperature representing the respective melting points, and this is really what is done at Ilsenberg, the temperature of 1,200 degrees Reaumur (2,732 deg. Fahr.) being taken as the standard value, while differences of temperature of 370 degrees Reaumur (864½ deg. Fahr.) have been found. It is

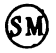
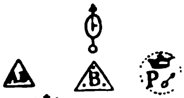
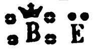
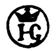
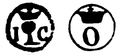
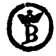
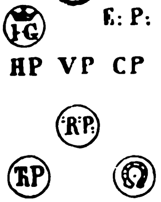
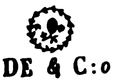
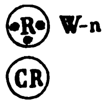
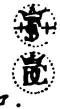
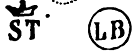
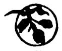
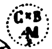
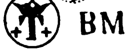
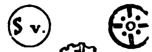
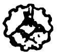
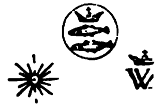
e noted that this mode of estimating relative melting points takes
ccount of the latent heat set free during the solidifying of the iron,
regards all the heat imparted to the water as if it were merely due
he sensible heat abstracted from the iron during its cooling down
n the melting point. No doubt this fact introduces an error, while
r errors may be induced by the want of care in pouring the iron
the water just before setting; but these errors do not affect the
e of the system as a rough-and-ready practical method of ascer-
ing the relative fusion points of different samples, and, as we have
, it has been found effective and useful at the Ilsenberg foundery.

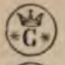
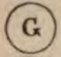
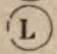
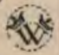
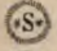
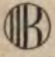
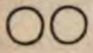
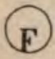
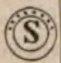
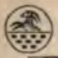
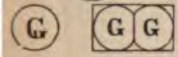
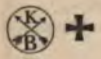
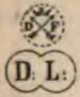
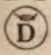
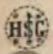
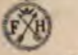
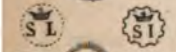
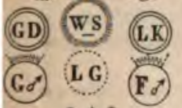
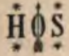
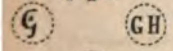
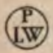
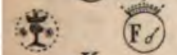
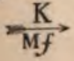
APPENDIX.

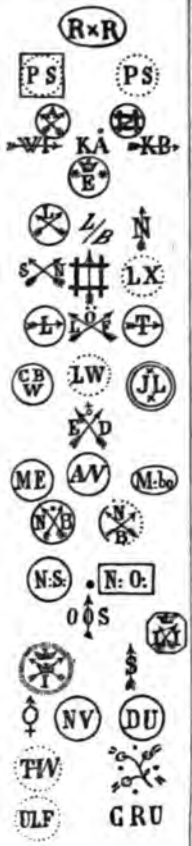
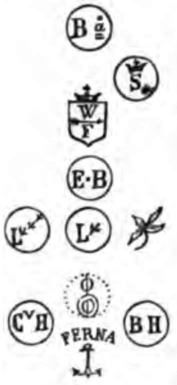
HOWING SEVERAL MARKS OF SWEDISH IRONS.*

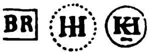
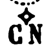
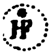
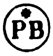
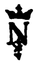
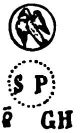
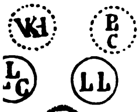
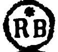
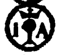
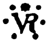
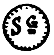
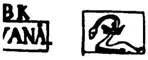
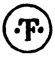
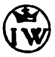
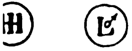
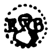
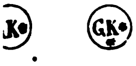
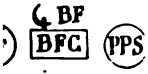
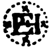
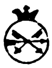
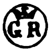
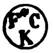
	Name of works.	Post-office.	Annual production in tons.	Principal ores.
		PROVINCE OF NORRBOTTEN.		
	Gellivore	Råneå	300	Gellivare.
		PROVINCE OF WESTERBOTTEN.		
	Hörnefors	Umnea	1,100	From middle of Sweden.
	Olofsfors	Nordmaling	300	Id.
	Robertsfors	Ånäsen	600	Id.
	Säfvare	Umnea	180	
		PROVINCE OF WESTER NORLAND.		
	Björkå	Nyland	150	From Lenaberg, Norberg, and Utö.
	Forsse Graninge Sollefteå	Nyland	1,400	Id.
	Galtström	Sundsvall	380	From Utö, Bisplberg, etc.
	Gideå	Örnsköldsvik	350	
	Gåhlsjö	Nyland	170	From Lenaberg, Norberg, and Utö.
	Lögdö	Sundswall	175	From Stochenström, Utö, etc.
	Matfors	Id	200	
	Norafors	Id	175	From Staf.
	Sörfors, etc	Id	600	From Roslag.
	Torpshammar	Id	230	
	Westtanå	Hernösand	340	
	Åviken	Sundswall	130	

Reprinted from the Report on Iron and Steel at Paris, 1867, by A. S. Hewitt.

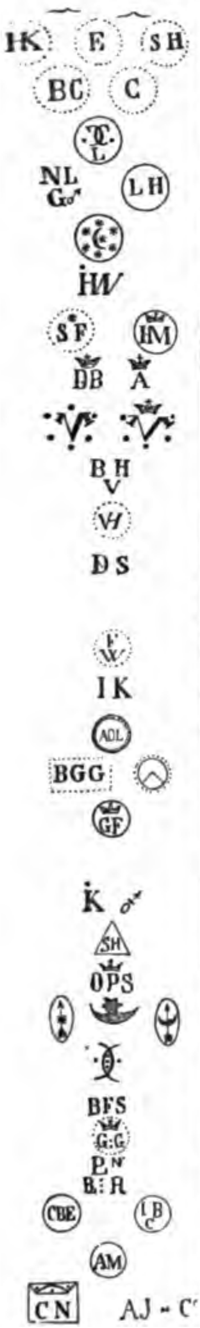
Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	PROVINCE OF GEFLEBORG.			
	Andersfors	Hudiksvall	150	
	Axmar	Gefle	1,100	From Utö, Enkärr etc.
	Forsbacka, (for steel)	Gefle	850	From Tuna, Hastberg, etc.
	Gamelstilla	Thorsåker	430	From Bispberg, Norberg, and Thorsåker
	Grönzinka	Gysinge	440	From Norberg, ec.
	Gysinge	Id	940	From Dannemor.
	Hammarby	Thorsåker	2,300	From Bispberg, Norberg, and Thorsåker
	Kungsfors and Ubrfors			
	Hofors			
	Montros			
	Robertsholm			
	Högbo and Sandviken	Gefle	....	From Bispbeg and Thorsåker.
	(For gun-barrels.) Kihlafors (For steel.)	Söderhamn	1,100	From Hammam and Norberg.
	Ljusne	Id	430	From Norberg, Iti, Striburg, Dannemoraetc.
	Långvind	Id	680	From Wigelsbo, Ut and Herräng.
	Mackmyra	Gefle	370	
	Orkelbo	Id	1,500	From Vintjern.
	Oslättfors	Id	600	From Bispberg, et
	Ström	Hudikswall	720	From Östanberg, e
	Svabensverk	Falun	550	From Vintjern.
	Tolffors	Gefle	960	From Bispberg.
	Woxna	Bollnäs	630	From Gymås and Örskog.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	PROVINCE OF UPSALA.			
	Elfkarleö	Tierp	430	From Dannemora.
	Gimo	Upsala	280	Id.
	Leufsta	Tierp	700	Id.
	Strömberg	Id	450	Id.
	Söderfors	Id	850	Id.
	Wattholma	Upsala	255	Id.
	Österby	Id	1, 500	Id.
	PROVINCE OF STOCKHOLM.			
	Forsmark	Tierp	520	From Dannemora.
	Skebo	Norrtelje	830	Id.
	Harg	Östhammar	430	Id.
	Rånäs	Stockholm	230	Id.
	PROVINCE OF STORA KOPPARBERG.			
	Avesta	Avesta	180	
	Dalfors	Gagnef	470	From Hamsart, Sörskog, and Gymås.
	Dådras	Falun	350	From Vinjurn and Skinnaräng.
	Fredriksberg	Gagnef	1, 100	From Byberg and Grängesberg.
	Fredshammar	Mora	770	From Åhl, etc.
	Farudal	Gagnef	650	Brom Åhl and Harmsarf.
	Garpenberg	Avezta	860	From Bispberg and Lång vik, etc.
	Gravendal	Gagnef	1, 100	From Grängesberg.
	Grängshammer	Säter	1, 100	From Gräsberg, etc.
	Hagge	Suedjebacken	1, 400	Grängesberg.
	Horndal	Avesta	510	From Bispberg, etc.
	Kloster	Hedemora	940	From Rällingsberg.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	Kloten and Granhult	Köping or Ramsberg	980	From Grängesberg, Lomberg, and Ramsberg.
	Korsä and Svartnäs	Falun	1,600	From Vintjern and Skinnaräng.
	Larsbo	Smedjebacken	600	From Ostanberg, Norberg.
	Limå and Noraå	Gagnef Falun	920	From Tuna Hästberg.
	Lindesnaes	Gagnef	1,500	From Gräsberg.
	Snöå		900	From Sommarberg, etc.
	Ludvika	Smedjebocken	1,600	From Ivike, Främmundberg, Finnås and Håksberg.
	Långö	Mora	270	
	Malingsbo	Wik	510	From Grängesberg, etc.
	Norn	Hedemora	280	From Bipsberg.
	Norså and Olofsfors	Smedjebocken	230	
	Nyhammar	Id	1,600	From Grängesberg and Ivike.
	Siljansfors	Mora	280	From Sörskog, etc.
	Stjernsund	Hedemora	280	From Bispberg and Norberg.
	Thurbo and Wikmanshyttan (Cast steel.)	Hedemora	760	From Bispberg and Norberg.
	PROVINCE OF WESTERÅS.			
	Baggå	Köping	470	From Gräsberg and Nyberg.
	Berntshammar	Id	410	
	Bjurfors	Norberg	270	From Norberg.
	Engelsberg	Id	320	Id.
	Fagersta	Id	1,200	Id.
	Ferna	Köping	1,700	From Gräsberg, Nyberg, and Grängesberg.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	Gislarbo	Köping	900	From Riddarhytta.
	Hallstahammar	Strömsholm	450	
 	Högfors and Persbo	Norberg	250	From Norberg.
	Jäder	Arboga	280	
	Karmansbo, etc	Köping	1,300	From Norberg and Grängesberg.
	Kolsva	Köping	1,200	From Stripa, etc.
	Ramgås	Westerås	940	From Östanberg, etc.
	Seglingsberg	Id	430	From Norberg.
	Skattmansö	Enköping	260	
	Skinnskatteberg	Köping	680	From Billsjö and Norberg.
	Surahammar	Westerås	1,400	From Norberg.
	Svanå	Id	760	Id.
	Trångfors	Strömsholm	190	
	Uttersberg	Köping	340	From Gräsberg, Tyskgrafva, etc.
	Westanfors	Norberg	190	From Norberg.
	Wirsbo	Westerås	430	
		PROVINCE OF ÖREBRO.		
	Aspa	Askersund	490	From Nora.
	Bofors	Ockiskoga	1,000	From Persberg and Nora.
	Bobr	Lindesberg	160	From Lomberg, etc.
	Bredsjö	Nora	170	From Ösjöberg, Gröndal, etc.
	Brefven	Kilsmo W. S. B.	350	From Nora and Lanna.
	Bångsmedjan	Nya Kopparberg	140	From Lomberg, etc.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
K	Degerfors Ö	Åtorp	150	From Dalkarlsberg an Striberg.
WC H	Degerfors N	Degerfors N.W. S. B.	850	From Persberg, Dalkarls berg, Striberg & Viker
K	Elfstorp	Nora	720	From Högborn.
PF	Frötuna	Arboga	390	
GB G WF D R	Common marks. Gammelbo	Company of Gammelbo. Ramsberg	270	From Ramsberg an Pershytta.
	Finnåker	Arboga	1,050	
	Grönbo	Id	220	
	Ramshytta	Nora	120	
GB	Garphyttan	Örebro	260	From Pershytta and M grafva, etc.
HH AH	Gryn	Pålsboda W. S. B.	1,020	From Nora.
V	Haddebo Ö	Id	210	Id.
BW BS	Haddebo N	Id	290	Id.
	Hammarby	Nora	1,000	From Hagby, Lerber etc.
MF W.S	Hasselfors	Hasselfors N. W. S. B.	600	From Dalkarlsberg, Str berg, and Viker.
HS LSH C H	Hellefors	Grythyttehed.	2,810	From Lomberg and Sva vik, etc.
NE	Högfors	Nya Kopparberg	190	Id.
S×L LS	Lassåna	Laxå W. S. B.	430	From Nora.
HSH	Laxå	Id	850	From Dalkarlsberg, Str berg, and Viker.
	Petersfors	Nora	150	From Jernboås.
	Ramsberg	Ramsberg	150	From Stråssa and Blank
PV	Ramshytta	Id	140	Id.
K·	Rockesholm	Nora	260	From Skårhytta and Hö born.
DRS	Rockhammar	Arboga	1,050	From Stripa, Mossgnefv etc.
	Sikfors	Grythyttehed.	150	From Finnberg, etc.
CWS Mn	Skogaholm	Pålsboda W. S. B.	510	From Nora.
	Skyllberg	Hallsberg W. S. B.	800	From Nora.

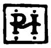
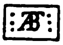
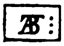
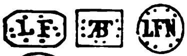
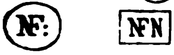
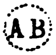
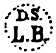
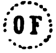
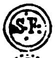
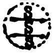


Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	Stjernfors	Nya Kopparberg	470	From Lomberg and Svartvik, etc.
	Svartå	Svartå N. W. S. B.	700	From Dalkarlsberg, Striberg, Viker, & Persberg.
	Walåsen	Carlskoga	360	Id.
	Willingsberg	Örebro	500	Id.
	Wrethammar	Ramsberg	130	From Stråssa and Blanka.
	Åbyhammar	Arboga	170	
	PROVINCE OF SKARABORG.			
	Forsvik	Karlsborg	300	From Nora.
	Fredriksfors	Wassbacken	270	Id.
	Lagerfors	Moholm W. S. B.	300	Id.
	Ribbingsfors	Mariestad	350	Id.
	Skagersholm	Finnerödja W. S. B.	430	Id.
	PROVINCE OF CARLSTAD.			
	Ackbärn	Christinehamn	550	From Filipstad.
	Bada Ö	Sunn	150	Id.
	Björneborg and Jonsbol	Christinehamn	1, 000	From Persberg, Dalkarlsberg, Streberg, & Viker.
	Borgvik and Brunsberg	Carlstad	2, 000	From Persberg.
	Brattfors, etc	Id	850	Id.
	Charlottenberg	Arvika	400	From Persberg and Nora.
	Dömle	Carlstad	470	From Filipstad.
	Edsvalla	Id	940	Id.
	Elfsbacka	Carlstad	1, 280	From Nordmark and Finshytta.
	Fredros	Arvika	425	
	Glasfors	Ökne	340	
	Gustafström	Grythyttehed	550	From Persberg, Björnhöjde, Fagerberg, and Långvan.
	Helybodafors	Arvika	160	

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
K:	Håkanbol	Åtorp	230	From Dalkarlsberg.
CHH KB PS	Högfors	Sunne	630	
BE UvA	Kolsäter	Ökne	210	
J.S. OPS/C	Krontorp	Christienhamn	370	
RF, GF, IE, UF.	Linnartsfors	Ökne	800	
LP GE	Leajöfors	Filipstad	1,200	From Långban and Persberg.
NM JCA CCG	Lethafors	Råda	220	
K: PC	Lidefors Ö	Åtorp	150	From Dalkarlsberg and Striberg.
K: OL	Lidefors N	Id	160	Id.
S:H LNS	Lindfors	Carlstad	850	From Persberg.
OAS MM	Löfstaholm	Sunne	280	
MFS	Mitandersfors	Id	200	
OK MB	Mölnbacka	Carlstad	850	From Persberg.
GL Nm	Niclasdam	Christinehamn	280	
INN	Noreborg	Arvika	140	
HK N	Norum	Carlstad	150	
Q	Qvarntorp	Id	170	
I GG	Ransäter Ö	Id	160	
F EF	Ransäter	Id	180	
HK CGG	Rans er N	Id	160	
RD RH GS	Rottnedal	Sunne	640	
6 LD 6	Rämen or Lijendal	Filipstad	680	From Långban, Persberg, and Filipstad.
IL Ł W CLG SB	Storfors	Christinehamn	1,530	From Persberg and Nykroppa.
HK	Stömnedj	Carlstad	260	
CÜ ÜG	Svaneholm	Åmål	400	From Filipstad.

Mark.	Name of works.	Post-office.	Annual production in tons	Principal ores.
WR RF	Sälboda	Arvika	1,230	From Persberg.
Æ	Thorsby	Sunne	630	
Œ LB ÆB G.F ØF W:F	Uddeholm	Råda	4,300	From Taberg, Nordmark, Persburg, and Långban.
OPS	Wassgårda	Christinehamn	220	
	Wägsjöfors	Sunne	170	
	PROVINCE OF ELFSBORG.			
BF	Bäckefors	Åmål	1,520	From Persburg.
CD LF	Christinedal	Id	460	
IGE AL GM	Forsbacka	Id	390	
KB	Kollerö	Uddevalla	700	
V	Upperad	Wenersborg	320	
	PROVINCE OF NYKÖPING.			
F	Forssa	Katrineholm W. S. B	260	
Z	Forssjö	Id	310	From Skalunda, etc.
K	Krämbol	Id	230	
Ny	Nyby	Thorshälla	340	
	Nyköping	Nyköping	630	
	Skepsta, (steel)	Björnlunda W. S. B	350	
	Smedstorp	Malmköping	170	From Staf.
GS W	Virå	Norrköping	260	
	PROVINCE OF ÖSTERGÖTLAND.			
B R	Borggård	Tjellmo	260	
I B	Borkhult	Söderköping	190	From Utö, etc.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
B b	Boxholm	Boxholm	640	
BB	Börggjöl	Norrköping	160	
ЭE F:G TGE N:G	Finspong	Id	2,200	From Upsala, Striberg, Utö, etc.
C:F:	Folkström	Tjellmo	510	
DC	Godegård	Hallsberg W. S. B.	270	From Nora and Sanna.
CDB	Grytgjöl	Tjellmo	180	
H	Hult	Norrköping	250	
HJ	Håfla	Id	600	From Nora.
NT	Hättorp	Tjellmo	170	
ÆF Λ	Ljung	Linköping	550	
Lå	Lemneå	Tjellmo	310	
MW	Motala Werkstad	Motala	2,100	
S-C	Skönnarbo	Tjellmö	380	
.m.	Sonstorp	Norrköping	550	
	PROVINCE OF CALMAR.			
Am A	Ankarsrum	Westervik	830	From Stenbo, Nartorp, Sjösa, Herräng, and Norberg.
E	Ed	Söderköping	220	From Stenbo, Herräng, Utö, and Nartorp.
HB	Falsterbo	Westervik	260	From Skramstad, Öbalen, and Utö.
TF	Fogelfors	Staby	310	From Striberg and Sahlsta.
T	Tofverum	Wimmesby	170	
	Öfverrum	Åtvidaberg	350	From Sjösa, Utö, Stensnäs, Olofsrum, etc.

Mark.	Name of works.	Post-office.	Annual production in tons.	Principal ores.
	PROVINCE OF JÖNKÖPING.			
	Eckersholm	Jönköping	140	From Taberg.
	Göthafors	Id	180	Id.
	Hörle	Wernamo	390	Id.
	Lindefors	Wrigstad	290	Id.
	Nissafors	Jönköping	370	From Taberg and Nora.
	PROVINCE OF KRONOBERG.			
	Bökholm	Wexiö	160	
KS	Klafreström	Id	150	
	Lessebo	Id	240	
	Orrefors	Id	240	
	Stenfors	Id	210	
	Säfsjöström	Id	190	

For information as to the prices and qualities of the irons, one can write directly to the forges themselves. For example: "Brukskontoren à Säfsjöström, Wexiö, Sweden;" or "Brukskontoren à Nissafors, Jönköping, Sweden," &c.

But as all the marks are not indicated here, and since all the forges have agents, it will be better to ask the name of their agent, who will be able to give all the necessary information.

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